The Impact of Agricultural Change and Farming Practices on Farmland Trees and Hedgerows as a Landscape and Ecological Resource, with Specific Focus on Kent

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Abstract

A decline in the length of hedgerow boundaries and number of farmland trees in the agricultural landscape triggered the destruction and deterioration of many important habitats, species and their specialised microhabitats. This research studied two contrasting physiographic regions, the Low Weald and the Downs in Kent, to identify the extent of these losses. It was hypothesized that changes in the agricultural landscape has been affected by the modification and development of the agricultural system post-World War and that these changes would differ between the two physiographic regions. This research confirmed that post-World War, the length of hedgerow boundaries has declined and even with environmental incentives to increase the planting and maintenance of hedgerows, the length is still not what it was pre-World War.

To analyse the ecological benefits that farmland trees are providing within the environment, the types and number of microhabitats present on farmland trees were recorded. It was hypothesized that because of farming management taking place, trees on farmland would produce some of these specialised microhabitats predominantly present on mature trees; but the numbers produced would be lower on younger trees. This research has confirmed that young and mature trees can produce at least one specialised microhabitat within a farmland system. The type and number of microhabitats present varied with the species of tree. Species found on both physiographic regions had nearly the same range of microhabitats present, and the size of the tree was found to not affect the ability to produce a microhabitat. This research concludes that agricultural practices can be a precursor for some specialised microhabitats to form on farmland trees.

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Contents

Illustrations

List of Figures

Section 2

Section 3

Section 4

List of Tables

Section 2

Section 3

Section 4:

1. Introduction

1.1: Britain's Countryside Changes

Britain's countryside has been through continuous landscape changes throughout history; but it was from the 1800s to after World War Two that Britain's countryside went through a series of dramatic changes that altered the structure of the agricultural landscape. This was a period of agricultural intensification, generated by the increased demand on British farmers to produce a greater supply of food to feed the growing population and as a strategic response to food shortages during times of war. The intensification and mechanisation of farming practices instigated the extensive loss of Britain's most prominent features, hedgerows and trees.

Many hedgerows and trees, on and surrounding Britain's farmland have been uprooted, destroyed or neglected throughout history, albeit for differing reasons. For example, during pre-historic times (Neolithic onwards) trees were removed to make way for agriculture, whereas in the present day trees are being removed to make room for urban development. The extensive loss of these landscape features over the years resulted in the loss and decline of many ancient habitats and their dependent species, hindering species dispersal because of the lack of habitat connectivity between different locations.

The intensification of farming practices before and after World War Two caused a vast amount of damage to habitats and species within Britain's landscape. A change of perception regarding the countryside occurred in the 1980s, with academic research highlighting how valuable hedgerows and trees were as an ecological resource. There was also a decline in the demand for food from British farmers in the 1980s because of the competition with cheaper imports from other countries, thus reducing the intensity of farming. The amount of hedgerow and trees lost because of intensification was also highlighted, prompting local and governmental to introduce policies to protect, maintain, extend and restore Britain's hedgerows and trees to enhance the availability of farmland habitats in Britain. The policies introduced included the 'Hedgerow Regulations Act' in 1997 under the 'Environment Act' in 1995, which were created to protect, maintain and extend hedgerows, with specific focus concerning those aged thirty years and over. The introduction of these policies and schemes encouraged and provided a greater focus on environmentally friendly approaches to managing hedgerows and trees on farmland. This project is a case study in Southern England investigating if the implementation of these policies has caused an increase in the length and quality of hedgerows.

Alongside hedgerows, many ancient and mature trees have also been removed from the agricultural landscape over time. Ancient trees are considered to be a greater ecological resource compared with younger trees because of the certain microhabitats which only occur if the tree has aged or gone through various environmental events, like storm damage. For example, microhabitats like cavities occur naturally in an oak tree aged over two hundred years. With the removal of many ancient trees also meant many specialised habitats and species went into decline.

There has also been an extensive problem involving the number of dead or decaying trees that have been removed from the environment. Like ancient trees, dead or decaying trees also produce some of the most unique microhabitats within the environment. The unsightly appearance of these trees can put landowners off from having them on their land for aesthetic reasons. A lack of understanding and depth of knowledge involving the microhabitats and the species that rely on the decay and rot to survive also meant that these trees were not viewed as an important ecological resource within the environment. The decline in these rare microhabitats, because of the lack of mature trees in Britain, has prompted research to investigate if natural events like storm damage, which generate processes which create these specialised microhabitats, can be replicated and mimicked by humans onto younger trees to create precursors for microhabitats to develop. If that research suggests that the processes replicated onto younger trees can produce these microhabitats then more trees within the environment can have these practices implemented on, to encourage and increase the specialised microhabitat diversity within Britain's environment. This study will also include an assessment on the number of microhabitats present on farmland trees. Existing research on the occurrence and variety of microhabitats produced have mainly been studied on trees in larger woodland or forest systems. This project however, is focused on the microhabitats present on trees within the farmland system, as it can be questioned that some farming management practices, including the use of the flail, are generating some of these specialised microhabitats without it being realised.

1.2: Aims of this Study

The ecological importance of hedgerows has been extensively researched, with various studies highlighting the importance of hedgerows for agricultural biodiversity. However, there is limited research on whether farmland trees sustain damage from farming management practices and if they do, do they create precursors which can encourage trees to produce specialised microhabitats.

This research is therefore investigating the impact that agricultural changes and farming practices have had on farmland hedgerows and trees as a landscape and ecological resource, with specific focus on Kent in South East England. This research focused on two landscape types, the 'Low Weald' and the 'Downs'. The main objectives of this study were to investigate:

- To what extent has the agricultural industry between 1946 and 2015 affected the density and quality of hedgerows in the study area?
- To what extent has agricultural industry between 1946 and 2015 affected the numbers of hedgerow and farmland trees in the study area?
- To what extent have hedgerows been replaced by other farmland boundary types or lost entirely?
- Are hedgerow density and number of farmland trees dependent on landscape type?
- To what extent have modern hedge management practices created microhabitat precursors in hedgerow trees?

2. Hedgerows, Trees and Landscape Changes in Britain

2.1: Introduction to the History of Britain's Agricultural Landscape

Many agricultural landscape changes and biodiversity losses that have occurred in the British countryside have been caused by changes in the management of semi- natural habitats. Management techniques practised on many farms today have been based on traditional methods used in the past. In the past, protecting the environment from damage caused by management practices was not a local or national concern (Sutherland, *et al.,* 2006). Today these traditional methods can be considered to have destructive impacts on the environment. The farming industry has had an effect on Britain's environment with its increased intensification and productivity (Sutherland, *et al.,* 2006) with many hedgerows being removed in the twentieth century as they were considered a hindrance to farming efficiency (Sterry, 2007). The intensification of agriculture is arguably the main factor that has led to the degradation and loss of field boundaries, including hedgerows and hedgerow trees (Devaeminck, *et al.,* 2005). This forms the main focus for this study.

A feature of the agricultural landscape that can be seen from post medieval times to the present is land enclosure. This landscape characteristic consists of areas of land being surrounded by a linear feature including hedges, fences, walls, trees or ditches (Pryor, 2011). Between the sixteenth and eighteenth century many hedgerows were planted because of the process of land enclosure (Sterry, 2007). Hedgerows were planted to, indicate landownership, the location of field boundaries and to act as stock proof barriers to protect crop fields from animals and prevent animals escaping their fields. There are two types of hedgerow; ancient hedgerows which have existed for many hundreds of years and more recent enclosure act hedgerows. As defined by Rackham, (1986) Kent is a largely ancient landscape and was 'well hedged by the late Middle Ages' (p.197). This indicates the enclosure of land with ancient hedges rather than hedges created because of the Enclosure Acts of the post medieval period, especially in 1750-1850s. Hayes and Miller, (1995) confirms this by noting that the parliamentary Enclosure Acts had little effect on the Bromley area of London, previously once part of Kent, with most hedges possibly dating back to the fourth century. Taylor, (1988) also notes that most hedges in Kent and similar ancient countryside in Devon, Norfolk and Cornwall, are medieval and may have dated back to the Romans or the prehistoric periods. Therefore, hedgerows considered ancient tend to be more important concerning the biodiversity and conservation of many species. Enclosed land is a key feature of Britain's landscape, but, with recent periods of agricultural expansion came declines in the number of fields being enclosed by features such as hedgerows. This consequently, removed vital habitats within the agricultural landscape, affecting its biodiversity and species richness.

Victorian High Farming during the eighteenth century was the era of agricultural stability, enabling British farmers to produce enough food to feed the expanding population (Stearman, n.d). This era saw the improvement of land drainage, restoration of farm buildings and the introduction of fertilisers in the 1830s, imported from South America to enrich the light soils. The improvements within the farming industry led to further developments to the roads, maintaining communications and commodity prices between regions (Pryor, 2011). The prosperity of the Victorian High Farming era ended when the agricultural depression of the 1870s began. The agricultural depression in the 1870s was caused by the abolishment of the Corn Laws in 1846 because of the detrimental impact that the high prices of corn were having on the British population (Pryor, 2011). The depression also saw the fall in wheat and wool prices with British farmers facing competition from cheaper imports from other countries such as Australia. This also led to the decline in the number of sheep which had previously played a role in the crop rotation cycle, being replaced by imported fertilisers and manure (Pryor, 2011). These changes encouraged farmers to diversify and move into commodities where freshness was essential so they were not competing with imports; such as fruit, milk and vegetables (Pryor, 2011). This depression ended when the First World War started, but the effects would be felt until the start of the agricultural revolution after the Second World War (Coppock, 1964).

2.2: Pre, Inter and Post World War Agricultural Changes in the British Countryside

Britain's reliance on imported produce was highlighted during the First World War from 1914 to 1918 when merchant ships were at risk of being destroyed by the Germans and import supply routes became dangerous or cut off (NFU, 2014). With the threat of food shortages, the British government realised the importance of the British farmers and turned to them to feed the population. Campaigns and policies were brought in by the government to help productivity on farms, such as compulsory rationing and the Defence of Realm Act in 1914 which would enforce the ploughing up campaign in 1917 to turn pasture into arable production (NFU, 2014). This saw arable production increase by two and a half million acres with around nine million acres planted with potatoes and grains (Stearman, n.d). The government also purchased tractors in 1917 to replace over half a million horses previously used on the farms that were sent to the frontline, to increase efficiency and productivity (NFU, 2016). This was the start of mechanisation which would have a major impact on Britain's agricultural landscape during and after the World War periods.

The inter war years between the 1920s and 1930s presented a period of agricultural depression. The number of workers on farms fell because of the low wages (Bowers, 1985) as the worldwide surplus of produce led to the fall in prices (Armstrong cited by Yates, 2001). It was not until the Second World War from 1939 to 1945 that the agricultural depression eased with the government guaranteeing farmers agricultural prices (UK Parliament, 2016). From the 1930s motor manufacturers and agricultural engineers assembled farm equipment and tractors at a low cost and high volume which along with the use of artificial fertilisers encouraged farms to intensify and increased the speed and food output (Pryor, 2011). The Second World War provided the stimulus for changes in the countryside because of the increased development of mechanisation to maximise the production of food, (Coppock, 1964). Between 1939 and 1945 the area of arable land in England and Wales increased by sixty three percent to keep up the food production during the war (Pryor, 2011). After the Second World War the focus was on the food production for the country, but the impact that increased productivity inflicted on the surrounding environment and its nature was not recognised. Larger machinery with crop sprayers attached were used in the larger fields. Consequently, many trees and shrubs on farmland

and its boundaries were therefore removed to avoid damaging the sprayers. By 1946 the number of tractors being used on Kentish farms was around 7,729 with the number of horses in decline at 6,999 (Armstrong cited by Yates, 2001). The use of combine harvesters also rose between 1946 and 1950, from ninety five to three hundred and sixty seven (Armstrong cited by Yates, 2001), encouraging hedgerow removal and field enlargement.

The agricultural landscape and industry have gone through various transitions with geographers and other disciplines devising concepts to explain the phases that generated the changes. The first phase was the ‘productivist’ phase, occurring between the 1950s to the mid-1980s and was driven by the national government and later European aid through the Common Agricultural Policy (see table 2.1, p.9). This phase was fuelled by three processes; specialisation, intensification and concentration (Calleja, *et al.,* 2012) This period was characterised by the industrialisation and modernisation of the agricultural industry and led to capital intensive farms disconnecting British farms from the rural economy and its consumers (Ilbery and Watts, 2004). The second was the ‘post productivist’ phase, occurring during the 1990s and was a response to the concerns involving the degradation of the environment and the difficulties faced in the productivist phase (Ilbery and Watts, 2004). The concepts for this phase were the reversal of the specialisation, intensification and concentration processes seen in the productivist phase. This transition encouraged an extensive and more sustainable form of farming (Calleja, *et al.,* 2012) with demands for a more environmentally friendly farming system and a diverse agricultural economy to reconnect the producers and consumers (Ilbery and Watts, 2004). Demands for the preservation of landscapes, amenities and ecosystem services during this period saw the focus on agricultural production shift (Almstedt, cited by Lundmark and Sandstrom, 2013). However, some farmers continued to follow a productivist viewpoint causing both the productivist and post productivist phases of agricultural change to co-exist in a multifunctional agricultural system (Ilbery and Watts, 2004). This system then involved the practices from both productivist and post productivist being implemented (Calleja, *et al.,* 2012). Evidence of this happening can be seen within the EU where some countries in the Mediterranean may be entering the productivist phase while other northern countries in Europe may be in the post productivist phase. Therefore, policies applied within the EU like the Common Agricultural Policy, may use post productivst policies in countries still implementing productivist practices causing both concepts to coexist (Almstedt, cited by Lundmark and Sandstrom, 2013).

The productivist phase of the late twentieth century, particularly the 1980s, was when the damage to the biodiversity and species populations within the countryside was acknowledged. Over four hundred thousand kilometres of hedgerows had been destroyed since the 1950s (Pryor, 2011); largely because of the lack of management, urban development and the creation of bigger fields (Rackham, 1986). The popularity of gardening in the late twentieth century played an important role in maintaining the biodiversity that was lost during the war period. Many species including insects and birds found refuge in gardens as a result of intensive farming destroying their habitats (Pryor, 2011). Within the British countryside, wartime farming created long term consequences for many of Britain's farmland species. The destruction and neglect of many farmland habitats was caused by the rapid increase in mechanisation as well as the financial assistance given to many farmers to encourage them to intensify (Coppock, 1964). Therefore, the development and innovations through mechanisation and technology can be considered to be the two main drivers of landscape changes in Britain's countryside before, during and after the war period.

Policy, legislation and changes to agricultural practices	Purpose	Environmental Impact
1942: Scott Report, Land Utilization in Rural Areas	Identified the need to protect agricultural land and to improve farming practices.	Led to post-war policies on farming and landscape conservation.
1947: Agriculture Act -	Provided support to farmers to stabilise farming and encourage investment and mechanisation.	Led to innovation and investment in farming, with impacts such as field enlargement and hedge removal.
1947: Town and country Planning Act	To restrict the growth of cities. Land owners had to get permission to develop.	Controlled and restricted urban sprawl into the countryside. Provided stability essential to capitalisation of farming.
1949: National Parks and Access to the Countryside Act	Allows the designation of Areas of Outstanding Natural Beauty (AONB).	Focuses on the conservation and enhancement of a landscape.
1973: Entry to European Economic Community and CAP	The UK joined the European community.	Agricultural subsidies. Encouraged intensification.
1986: Agricultural Holdings Act	Allows agricultural holdings to be let to a tenant.	Provided security for tenants who had a long term investment.
1991: Countryside Stewardship Scheme	An agri-environmental scheme which gave an incentive for people to manage their land in an environmental friendly way.	Aimed to manage, improve and protect the environment
1995: UK Biodiversity Action Plan (BAP)	To decrease the loss of species rich hedgerows and maintain the number of hedgerow trees.	Ancient and species rich hedgerows were included in this plan as a priority habitat.
1997: Hedgerow Regulation Act	In response to high rate of hedgerow removal	To maintain, protect and extend hedgerows.
2005: Environmental Stewardship	Replaced the Countryside Stewardship Scheme	Encouraged effective environmental management with sustainable practices

Table 2.1: Policies, legislations and changes to agricultural practices post world war.

2.3: Importance of Britain's Hedgerows and Trees

The concept of biodiversity can be seen as a tool to measure the important dimensions of biological systems (Maclaurin and Sterelny, 2008). Biodiversity is considered to be the variety of different species such as animals, plants and micro-organisms within the system where they interact and live (WWF, 2015). The levels of biodiversity in a system are not just measured by the number of species present but on the types; because systems depend on different types and combinations of organisms to function (WWF, 2015). Biodiversity is an important feature to conserve because it enables ecosystems to function (Maclaurin and Sterelny, 2008). If aspects of an ecosystem are displaced or destroyed it can have a disruption on all ecosystems as species fight to survive, either within their original ecosystem or within another. Human development and agricultural expansion meant many habitats have been destroyed or disrupted, which has altered the structure and decreased the biodiversity within some ecosystems. For example, hedgerows, hedgerow trees and individual lone trees have gone into decline because of the agricultural expansion and human development that has occurred since the late 1800s; resulting in the decline of habitats available on farmland for various species.

Historically, habitat fragmentation and destruction are viewed as factors contributing to the biodiversity loss of a habitat (Sutherland, *et al.,* 2006). In the UK around three quarters of its land is farmed and depending on the management of the land, agriculture can either be good or bad for surrounding wildlife (RSPB, 2016). The specialisation of Britain's farming industry in the last century meant many farms switched from pasture to specialise in arable production (Pryor, 2011). Over the last half century, intensification and unfarmed habitats have resulted in the biodiversity decline on agricultural landscapes (Orlowski and Nowak, 2007), including the widespread removal of hedgerows (Boughey, *et al.,* 2011). To facilitate the changing practices on farms with the areas of productivity increasing and the use of larger machinery, approximately half of Britain's hedgerows were uprooted (Croxton, *et al.,* 2004).

One of the most threatened agricultural landscapes in Western Europe is the network of hedgerows (Burel and Baudry, 1995). Hedgerows are considered to be managed lines of woody vegetation which act as a barrier (see figure 2.1, p.11) between different fields (Staley, *et al.,* 2012). Hedgerows and hedgerow trees are important linear landscape features of the British countryside dating back to medieval times (Rackham, 1986). They provide a valuable habitat for a variety of species (Croxton and Sparks, 2002) and are essential in promoting and sustaining biodiversity in the agricultural landscape (Boughey, *et al.,* 2011). The importance of having a hedgerow used as a field boundary is viewed differently by different landowners as hedgerows can have both positive and negative effects on the neighbouring fields. On the one hand hedgerows can act as a windbreak protecting nearby crops and smaller saplings from bad weather and they can also prevent soil erosion (Devlaeminck, *et al.,* 2005). Hedgerows can also absorb runoff from chemicals and pollutants caused by fertilisers and pesticides preventing the soils and crops from absorbing too much (Devlaeminck, *et al.,* 2005). However, the disadvantage of having hedges includes shade, which can cause nearby crops to perish and increase competition for water between the crops, hedgerows and nearby trees (Devlaeminck, *et al.,* 2005).

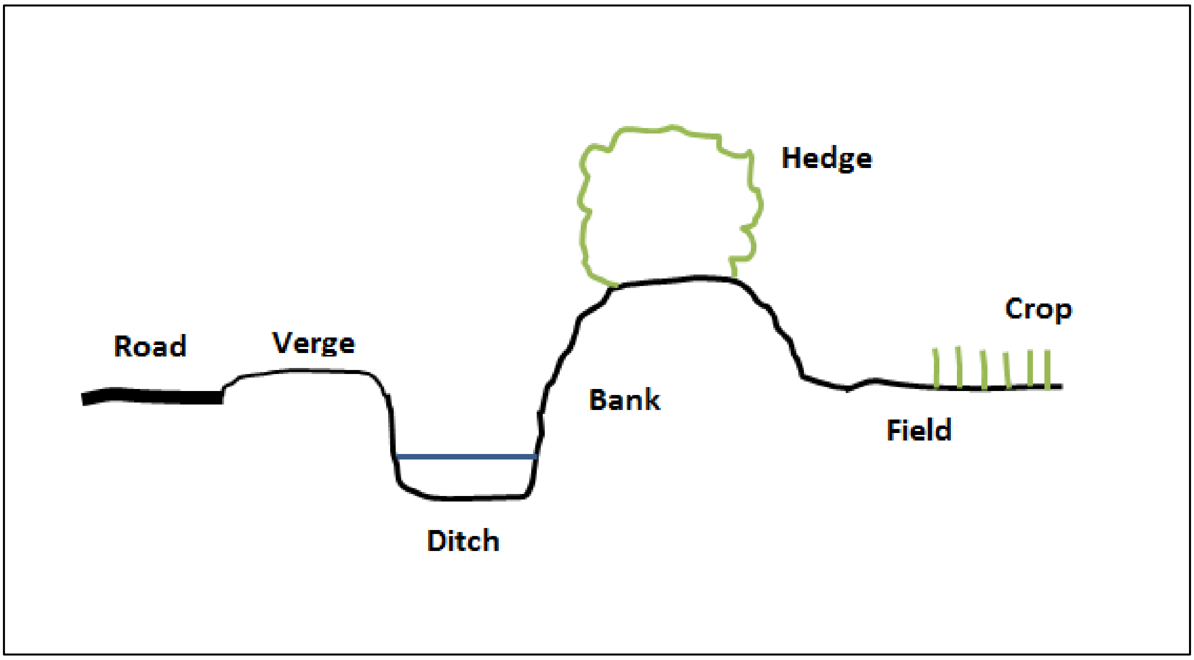

Figure 2.1: Idealised cross section of a hedge with ancillary elements.

(Adapted from: Dowdeswell, 1987, p.45).

Agricultural expansion during the Victorian High Farming era meant one hundred and twelve thousand kilometres of field boundaries which included hedgerows were removed (Pryor, 2011). From the 1800s to today the Victorian High Farming era removed the least amount of field boundaries and hedgerows compared with the post-World War years.

Approximately half the hedgerows in Britain since 1947 have been lost (Sparks and Martin, 1999) and data collected in 2007 in the Countryside Survey estimated that the length of managed hedgerows was approximately four hundred and two thousand kilometres in England; a decline of six point one percent since 1998 (Staley, *et al.,* 2012). The loss of thirty one thousand kilometres of hedgerow was connected with unmanaged hedgerows, becoming lines of trees or relict hedgerows because of the lack of hedgerow management (Staley, *et al.,* 2012). Surveys of British field boundaries showed that approximately twenty one percent which were classified as hedgerows in 1984 was classified as a different boundary in 1990 when resurveyed (Bannister and Watt, 1995). For example, in 1984 a boundary was considered hedged, then in 1990 a line of trees. The continued loss of Britain's hedgerows and the recognition of their importance to Britain's countryside led to concerns regarding the effect the loss was having on the farmland species that use them as a habitat (MacDonald and Johnson, 1995). This prompted the recognition of hedgerows as an ecological importance with a vulnerable conservation status (Boughey, *et al.,* 2011).

British hedgerows have faced policies (see table 2.1, p.9), both encouraging their growth and construction and of their removal and destruction. The seventeenth, eighteenth and nineteenth centuries saw the planting of hedgerows (Hackett, 1976); with the Enclosure Act being enforced in the eighteenth century. This act encouraged the construction of hedgerows, to block the movements of animals to improve breeding and to protect crops from roaming herbivores (Forman and Baudry, 1984).

However, after the Second World War governmental policies and financial incentives were introduced to encourage the removal of Britain's hedgerows. The removal of hedgerows during this time was in response to the intensification of the farming industry because the larger machinery used on farms could not manoeuvre around small fields and the government wanted Britain to be self-sufficient when producing food (RSPB, 2016). The Agricultural Act of 1947 was passed to promote and maintain an efficient and stable agricultural industry (Bowers, 1985). This Act guaranteed a minimum price for agricultural products to protect the farmers and their workers from the fluctuations of the market (UK Parliament 2016).

The introduction of the European Union agri-environmental policy during the late 1980s (European Commission, 2015), encouraged farmers to value their environmental resources as the policy brought value to the environment (Calleja, Ilbery and Mills, 2012). The rapid decline of Britain's hedgerows generated agri-environmental schemes to be created which were aimed at encouraging farmers to enhance and protect the environment on their land (European Commission, 2015). These schemes provide payments to farmers who commit themselves for a minimum of five years to use farming techniques and practices that are considered environmentally friendly (European Commission, 2015). Many of these schemes provide financial support for farmers to carry out environmentally sensitive hedgerow management (Boughey, *et al.,* 2011).

The continued understanding concerning the biodiversity on farmland is improved by the understanding of the ecological benefits hedgerows provide and how their efficiency as an ecological resource are being affected by other factors; such as the hedge's physical structure (Boughey, *et al.,* 2011). Understanding how hedgerows are affected by different management factors is also needed to ensure the agri-environmental schemes are effective (Boughey, *et al.,* 2011). For example, forty one percent of the length of England's managed hedgerows is involved in the Environmental Stewardship, adopted in 2005. This agri-environmental scheme aims to reduce the cutting frequency of hedgerows to increase the availability of berries and flowers for the wildlife (Staley, *et al.,* 2012). Thirty two percent of managed hedgerows in England are involved in the most popular agri-environmental scheme where hedges are cut every two years (Stayley, *et al.,* 2012). Since 2005 seventy percent of farmland in England is involved in agri- environmental schemes and as a result farmers and land managers have restored or planted thirty thousand kilometres of hedgerows and manage forty one percent of English hedgerows. This, as a result, has increased the breeding populations of farmland birds, previously considered to be nationally scarce (Department for Environment, Food and Rural Affairs, 2014).

The importance of Britain's hedgerows, ecologically and historically, meant they became a designated priority habitat in the UK National Biodiversity Plan in 1995 and were protected under the Hedgerow Regulation of 1997 (Croxten, *et al.,* 2004). The Hedgerows Regulation Act was created to protect many hedgerows in the British countryside from being uprooted and destroyed. Hedgerows covered by this Act are considered to be, a length of twenty metres or longer or less than twenty metres but meets another hedge at each end located on or next to various different land uses such as agriculture (RSPB, 2004). Many hedgerow trees are also under protection by a tree preservation order, which limits any work being carried out on them (Natural England, 2014).

In Kent the Kent Biodiversity Action Plan was published in 1997 by the Kent Biodiversity partnership which documented the requirements to protect those habitats and species with wildlife value in Kent (Kent Habitat Action Plan, 2005). Kent is known as the 'Garden of England' (Kent County Council, 2011) and around a third of the land has some protection with the Area of Outstanding Natural Beauty status. Ancient hedgerows are a priority in the UK because of their habitat value for many species. They provide ecological corridors for species to travel and from linkages between landscapes. The 1980s saw a reduction in hedgerows in the UK because of the shift towards agricultural intensification. There is evidence to suggest that hedgerow management has improved with hedgerows being planted and many derelict hedgerows restored. Hedgerows are under pressure from; herbicides and pesticides, over management, pressures of development and fragmented landscape is risk to species (Kent Habitat Action Plan, 2005). Some of the action plan objectives for the restoration and recreation of hedgerows includes, giving priority to ancient hedgerows, hedgerows that reconnect with habitats, hedgerows that are a character feature of landscape for example the low weald, where many hedgerows were removed because of agricultural intensification (Kent Habitat Action Plan, 2005). Kent faced a further decline in its biodiversity levels, so in 2003 the Kent Environment Strategy was implemented to improve the biodiversity and the county's environment (Kent County Council, 2011). However, in 2010 Kent failed to meet the government's targets to halt the species and biodiversity loss. This failure indicates that a greater focus on strategies and practices needs to be carried out to ensure the biodiversity of the County increases. This project will explore the themes related to the importance of hedgerows and farmland trees in Kent.

Today, farmland provides feeding and breeding habitats for a variety of species meaning farming practices and management are crucial for supporting the surrounding wildlife. Studies have shown that the abundance and richness of bird species increases with the increasing height and width of a hedge. Narrow, shorter hedges are not usually favoured by most birds such as bullfinches, as larger and taller hedges can offer nesting opportunities, more food resources and protection from predators and the weather (Hinsley and Bellamy, 2000). However, not all bird species prefer larger hedges, for example, yellowhammers which opt for shorter hedgerows (RSPB, 2016). The RSPB works with British farmers and the government to develop an agricultural system to ensure that farmland birds have the resources they need to flourish, by offering advice on how best to protect and nourish their population to farmers. Hedgerows are a valuable resource for a variety of birds, invertebrates and mammals, providing a food resource, nesting site, refuge from predators and a corridor for movement (Staley, *et al.,* 2012). Forty seven species of conservation concern; thirteen of which are globally declining, use hedgerows as a primary habitat (Croxton, *et al.,* 2004). Therefore, the understanding and implementation of sufficient management practices on farmland are crucial to ensure these species thrive and increase.

Research has identified that some form of hedgerow management is needed to sustain its wildlife, as a lack of management can be equally destructive as over management (MacDonald, and Johnson, 1995). Over management such as trimming or intensive flailing is often done to reduce the amount of shade that the hedgerows produce on neighbouring crops (Croxton, *et al.,* 2004). However, over management of hedgerows can have a negative effect concerning food sources and nesting sites on farmland birds (MacDonald, and Johnson, 1995). Neglected and unmanaged hedgerows develop gaps as the hedgerows grow taller and thinner. This not only provides a poor quality habitat for wildlife but also affects the function of a hedgerow as a barrier between fields (MacDonald, and Johnson, 1995). However, it should be noted that hedgerows left unmanaged can turn into lines of trees, which can bring both positive and negative changes to the landscape. On the one hand the length of hedgerows and their habitats in the landscape will decrease but the number of tree habitats would increase. To choose which habitat to preserve and maintain on their land would ultimately be down to the farmers and landowners.

The cutting time of a hedgerow is an important factor farmers need to consider, to prevent the disturbance or destruction of the wildlife using the hedge at a particular time of year (Sparks, and Martin, 1999). Traditionally hedgerows would be cut from July, between harvests and in early autumn (Bannister and Watt, 1995). The RSPB however, advises farmers to wait until the end of winter to trim their hedgerows to ensure the wildlife has a food resource during the winter. The nesting season between March and August should also be avoided to ensure nests are not disturbed or destroyed (RSPB, 2016). Information and understanding on the appropriate methods for restoring neglected hedgerows is therefore important to ensure farmers receive the correct treatment methods to restore and maintain their hedgerows to produce the best habitat for farmland wildlife (Croxton, *et al.,* 2004). Therefore, information on management methods that benefit the environment and the farmer, such as the circular saw needs to be available. This can then encourage farmers to pick the best method for them as well as the environment; as many use a management method based on its cheaper costs, such as the flail trimmer (MacDonald, and Johnson, 1995).

By leaving a hedge uncut, many components of the hedge are capable, if permitted, to grow up and form substantial hedgerow trees (Pollard, *et al.,* 1974). Kent is an ancient landscape so many hedgerow trees were most likely left to grow over time, not planted as many elms of the enclosed landscape were (Pollard, *et al.,* 1974). There are a number of benefits that trees along farm boundaries can provide. Soil erosion is a major factor that affects British farmers which can lead to the loss of important nutrients and can affect the infiltration of water. This can be caused by the loss of hedgerows, heavier machinery and increase in field size. Trees would therefore help increase water infiltration and reduce soil and sediment flows (Woodland Trust, n.d).

Scattered trees on farmland also provide a unique ecological function that cannot be replaced by alternative environmental features (Manning, *et al.,* 2006). Scattered and hedgerow trees have been lost because of physical impacts like disease including Dutch elm disease, which has seen ash trees become the most frequent hedgerow tree over elms (Woodland Trust, 2014). Numbers of ash trees in Britain are also at a high risk of going into decline because of ash dieback disease; this could see a further decline in the number of hedgerow trees. Human impacts have also had an effect on the loss of hedgerow trees because of the lack of management and conservation initiatives, development, increase in field size and neglect (Rackham, 1986). Hedgerow trees were in abundance before the 1750s because of the value that wood had as a resource; but after 1750 hedgerows and hedgerow trees went into decline because of the reorganising of fields and introduction of agricultural subsidies (Rackham, 1986). This rise and decline was also replicated in the 1940s to the 1970s where a number of countryside features and habitats such as hedgerow trees were destroyed because the government brought in policies such as the Common Agricultural Policy in the 1960s. The destruction of these trees however, kept occurring from the 1980s until 2007 because of the lack of management (HedgelinkUK, 2015). The continuation of hedgerows and farmland trees is arguably down to farmers and the government working together so that policies are implemented that benefit both the environment and the farmers. Organisations such as the English Hedgerow Trust, Woodland Trust and the RSPB are trying to raise awareness of the importance of tree management on farms to ensure that the habitats support a wide variety of species. They highlight the importance of retaining dead and dying trees if they do not present a hazard because they support a variety of species such as insects or hole nesting birds (RSPB, 2008). However, the establishment of emerging new trees within hedgerows can be problematic for farmers, generating additional costs and impeding mechanical trimming causing populations of hedgerow trees to become vulnerable to decline and deterioration (Boughey, *et al.,* 2011). To ensure these ecologically valuable trees do not go further into decline the Hedge Tree Campaign was created to educate and raise awareness of their importance. This campaign gained thousands of supporters including farmers to help maintain the number of hedgerow trees (Hedgelink, 2013).

As a result of agricultural intensification biological diversity within the agricultural landscape decreased because of the deterioration of unfarmed habitats (Orlowski and Nawak, 2007). Many hedgerows and scattered trees are ageing so offer veteran properties which can support specialist wildlife that rely on aged features such as rot hollows and decaying wood (Woodland Trust, 2014).) Saproxylic insects (Jonsell, *et al.,* 1998) use features of dead trees as a food source (Orlowski and Nawak, 2007). Increased knowledge about the importance of the micro-habitats produced on these trees meant organisations such as The Wildlife Trust and the Woodland Trust manage and offer advice to farmers and landowners on how to keep these trees in a healthy condition for the surrounding wildlife (The Wildlife Trusts, 2016).

Up until the nineteenth century older trees were widespread throughout Britain; but because of changing land uses and abandoned management they began to go into decline (Rainius and Jansson, 2000). Today there is a generation gap between the old and the young trees with a lower proportion of the trees belonging to the older age group. Ancient farmland trees, especially oaks, are in decline and play a vital role in conserving the biodiversity of the system. The older a tree gets the higher its ecological importance; however, most specialist microhabitats like rot hollows, only occur when a tree is around two hundred years old Bengtsson, *et al.,* 2012). Trees this age are limited, so consequently, so are the microhabitats they create. A process called veteranisation is being applied to try and speed up the ageing process of younger trees to recreate these microhabitats via human intervention (Bengtsson, *et al.,* 2012). This process eradicates the removal of trees and uses younger trees already in the system. An international project involving England is being carried out to establish the management methods that are best for nature conservation. Some of the methods include recreating woodpecker holes, broken branches and horse damage (Bengtsson, *et al.,* 2012).

As the methods of veteranisation involve damaging a tree to encourage the ageing process to create these specialised microhabitats, it would therefore be interesting to study if these processes are occurring within the agricultural landscape as part of other management practices. Hedgerow trimming could result in hedgerow trees gaining damage such as broken branches and cuts (see figure 2.2, p.19). If hedgerows trees are sustaining damage that could essentially age them quicker, then it would ensure that trees already on the landscape could host these specialised microhabitats. Branch loss due to hedge management could, for example, simulate storm damage and create rot hollows that are important to saproxylic species.

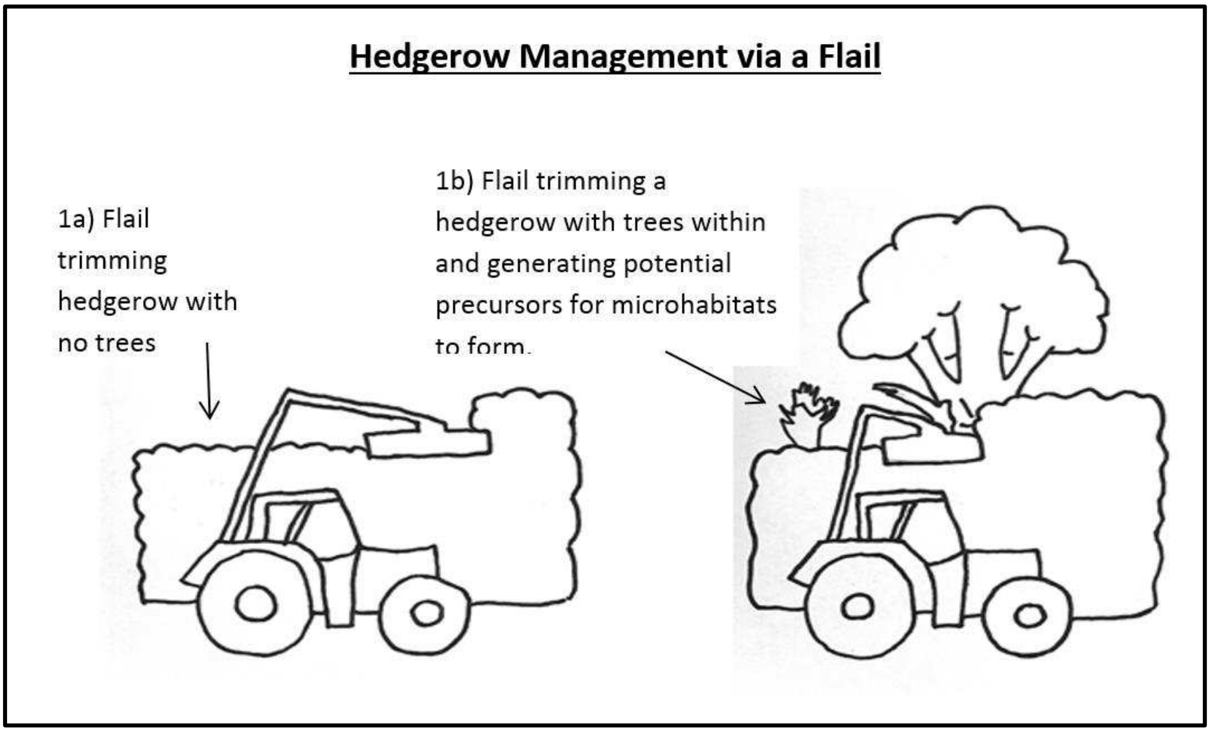

Figure 2.1: Interpretation of hedgerow management using a flail.

1a). Hedgerow trimming via flail with no trees. 1b).Hedgerow trimming via flail with hedgerow trees, highlighting the possible precursors of microhabitats on trees created by the flail.

Accidental or inflicted damage to a tree may, however, create opportunities for infection by unwanted diseases and should be taken into account in any veteranisation projects. Ash dieback (‘Chalara’) is caused by the fungus *Hymenoscyphus praxineus* and was first recorded In Britain in 2012. This disease has caused a vast amount of damage to ash population in Europe, killing young ash trees quick. However, there is evidence that mature ash trees can survive the disease if they are not attacked by another pathogen afterwards (Forestry Commission, 2017). Sudden oak death is also caused by a fungus *Phytophthora ramorum* and was first recorded in Britain in 2002. There is evidence that strains of this disease had little effect on the native oak species in Britain, killing more Japenese ‘Larch’ (Forestry Commission, 2017). Other tree species including, Douglas fir, beech, horse chestnut and sweet chestnut can also host this deadly disease. Dutch elm disease is the most serious of the three diseases with twenty five million ash trees succumbing to the disease by the 1990s (Forestry Commission, 2017). It is caused by the fungus *Ophiostuma ulmi* and *Ophiostuma* *novo-ulmi* and can be spread by beetles who feed on particular elm species. The symptoms of these diseases include leaf loss, crown dieback, bark lesions, early leaf death and falling and changes in bark colour (Forestry Commision, 2017). New elms can regenerate from an elm that has been severely damaged by Dutch elm disease as some of the original tree root can remain alive, enabling new growth to occur. Elms produce seedlings from an early age, so there may not be many older trees but there are still many younger elms growing. This may be why there is no requirement to report and trees suspected to have this disease, unlike the other two trees where people can report a suspected diseased tree.

Forest fragmentation in European agricultural landscapes is one of the most serious threats to wildlife populations (Dondina, *et al.,* 2016), increasing the danger of genetic isolation amongst species (Cox and Moore, 2010). Ecological corridors, traditionally hedgerows, are considered to be a management tool to mitigate the effects of this. Pollard, *et al.,* (1974) note that 'some five or six hundred plant species have been recorded in hedgerows, but only about half are sufficiently frequent to be thought of as hedgerow plants, and practically all are found in other habitats, such as woodland or grassland" (p.71). This richness provides the potential for hedgerows to act as corridors for both woodland and grassland species. Trees and hedgerows are crucial in ensuring the connectivity of the landscape, providing valuable habitats, food and shelter for a vast array of plants and wildlife, including birds like woodpeckers, bats and insects like butterflies (Hodge, 1990). Hedgerows are crucial in maintaining connectivity for mammals in agro ecosystems, with continuous hedgerows essential for low dispersal arboreal species (Dondina, *et al,,* 2016). A well-developed hedgerow enhances the availability of ecological resources as the effectiveness of hedgerows as ecological corridors depends on their internal structure and quality. Research by Dondina, *et al.,* (2016), suggests that for the European badger and hazel dormouse hedgerows need to be continuous in the landscape. Fragmentation alters the structure of species populations isolating them into smaller sub populations. Similar research also indicates that many species of European bats (Downs and Racey, 2006) utilise linear structures which provide commuting routes between patches of foraging land (Verboom and Spoelstra, 1999).

Poor quality and discontinuous hedgerows proved detrimental to some farmland birds and small mammals. The hedgehog is a declining species in the UK because they are a mobile species which tend to use linear features like hedgerows for a habitat and traveling corridors. Moorhouse, *et al,.* (2014) identified that connective semi-natural habitats on farmland can be crucial for the survival of hedgehog populations. It is therefore important to define and preserve structural features of hedgerows to mitigate habitat fragmentation and restore hedgerow connectivity to enhance their effectiveness as ecological corridors.

The rise of conservation initiatives and environmental management has highlighted the importance of supporting biodiversity on farms. Agriculture produces around nine percent of the United Kingdom's greenhouse gas emissions, therefore planting trees on farms will provide benefits in absorbing emissions produced such as carbon dioxide. Enforcing sustainable agriculture is important as it can improve the condition of the environment while supporting production (Woodland Trust, n.d). Today, the UK has approximately three hundred thousand farms which manage approximately seventy five percent of the United Kingdom's land surface and instead of destroying or harming habitats most farmers are implementing methods to maintain and preserve many features such as hedgerow trees on their land (UK Agriculture, 2015). It is therefore important to understand the habitats that farmlands can offer to enable the appropriate methods to be implemented by the farmers to encourage the growth of biodiversity rather than the reduction.

2.4: Kent's Geology

Kent is characterised by Rackham, (1986) as a region of 'ancient countryside', which is the product of continuity through the centuries with minor alterations since the 1700s. Kent was a landscape of enclosure before the eighteenth and nineteenth centuries, with hedgerows and farmland trees forming an important component of the landscape. Historically, Kent has been divided into the East and West, but the influence on settlement was predominately caused by the North South divisions relating to the geology which provide highly contrasted areas of countryside (Everitt, 1986). The development of Kent has been moulded by the economy and environment because of the contrasting geological conditions and structure, these soil types vary more than any other county in England of similar size (Garrad, 1954). The geological structure of Kent has therefore had a historical influence on the settlement of populations, development of roads and patterns of farming (Everitt, 1986).

Kent is characterised by the 'Weald Dome' which is the northward dip created by the folding of the sedimentary strata and is the main landscape characteristic of Kent's geological structure. Exposure of the various strata was caused by the removal of the Weald's crest from erosion (Young, 2004). There are nine overlaying geological successive formations from North to South in Kent, these are: London Clay, Thanet Beds, Chalk, Upper Greensand, Gault Clay, Lower Greensand, Wealden Clay, Wealden Sandstone and the deposits of Romney Marsh (see figure 3.1, p.23).

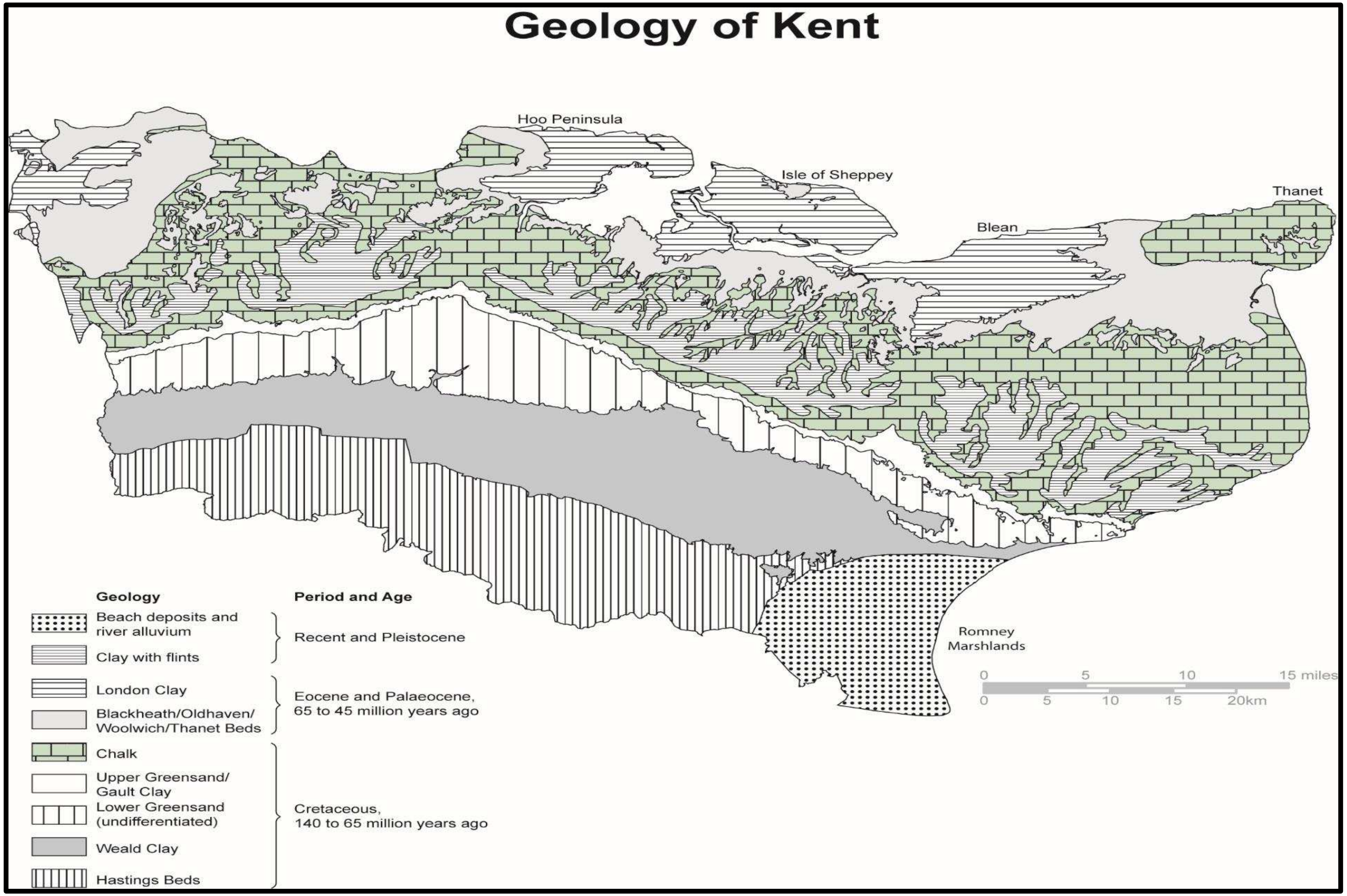

Figure 3.1: Geology of Kent

Figure 3.1 is a map highlighting the nine different geology types that make up the region of Kent.

Source: Young, C. (2004) p.1.

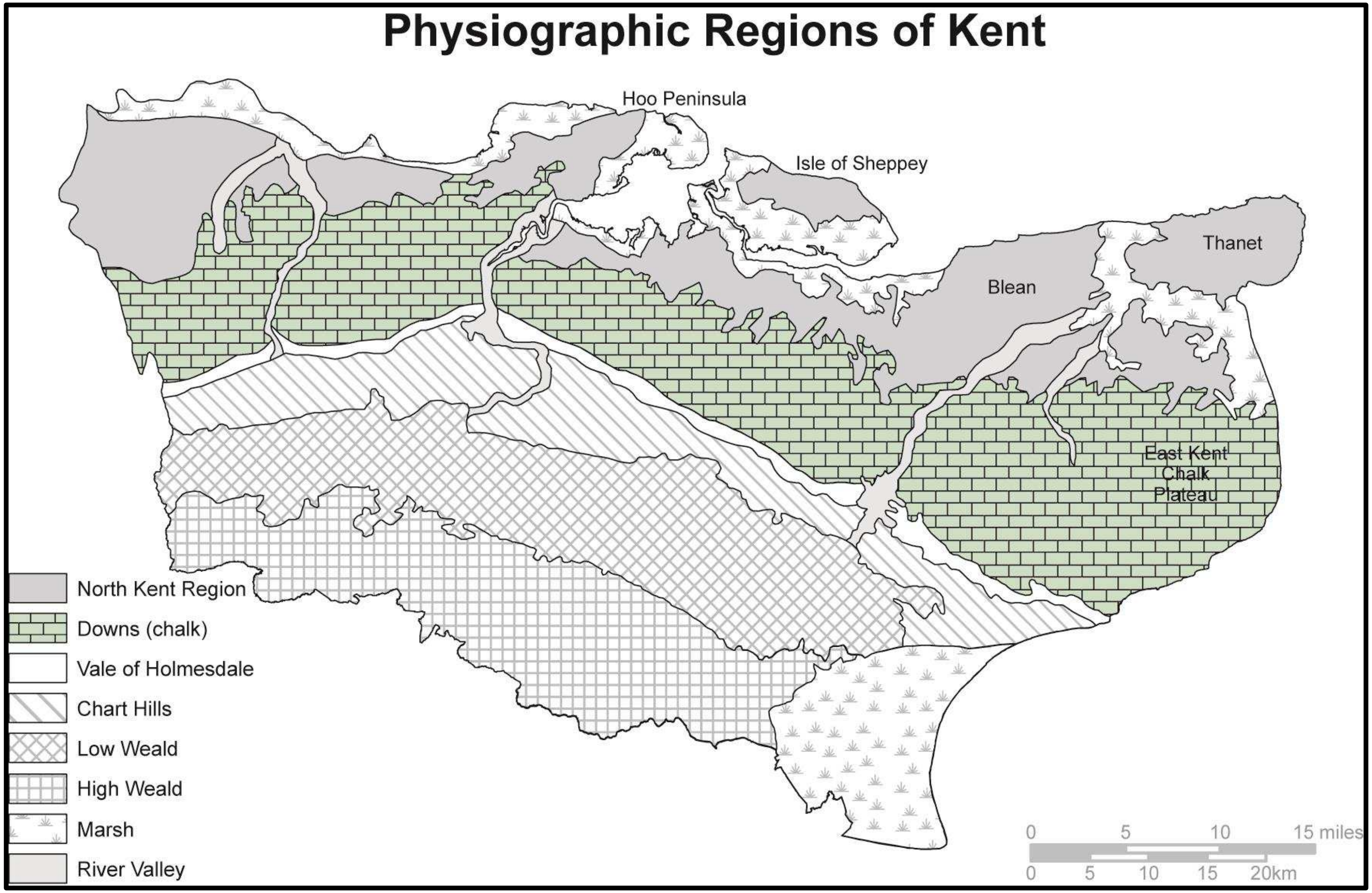

Figure 3.2: Physiographic Regions of Kent

Figure 3.2 is a map highlighting the eight physiographic regions of Kent

Source: Young, C. (2004) p.2.

Everitt, (1986), uses the term ‘pays’; (a term derived from the French for a region and its inhabitants who share common geographical, economic and cultural attributes) to describe the physiographic regions of Kent. Everitt divides the county into six regions; Foothills, Downland, Holmesdale, Chartland, Weald and Marshland (see figure 3.2, p.24).

These historical divisions are primarily a response to the varying fertility of the soil. This provides a useful means of understanding the landscape variations within the county as they have shaped the historical development of Kent. Described as the ‘Old Arable Lands’ and the ‘Original Lands of Kent’ the Foothills and Holmesdale played a role in the original Kentish settlement (Everitt, 1986). Accessibility to the sea, fertile and easily worked soils were the most important factors settlers considered. The fertility of the Foothills meant the land was so valuable during the early centuries that fields were cropped every year with the same rotation of wheat, barley and beans. Like the Foothills, Holmesdale also had fertile soil and a well-watered part of the countryside providing valuable land for arable production (Everitt, 1986).

On the other hand the limestone county of Kent including the Downlands and Chartland are unlike most other parts of England which provides very distinct countryside landscape characteristics. The chalk geology of the Downlands was colder, thickly wooded, hard to access because of the narrow valleys and provided less fertile soils then the clays of the Foothills and Holmesdale and was considered to be relatively poor countryside for agricultural potential (Everitt, 1986). Medieval people left this land uncultivated because they did not have the skills or machinery to cultivate the land. Today, modern farming methods have alleviated some of these cultivation problems enabling some of the land to be used for agricultural production. The Chartland on the lower greensand is also made up of rough, stony and infertile soil, so the land has been quarried for Kentish rag limestone since before the Romans. The lack of fertile soil meant most of the land was originally used as common pasture, with the development of parkland occurring in the early modern period (Everitt, 1986).

The Weald division is a historical pastoral region and is divided by the heavy clay soils on the low weald and the lighter sandstone soils on the high weald. The weald was mainly a pastoral region with arable only having local value, until the 1840s when two developments transformed the low and high weald. The first development was the invention of clay pipe drainage, enabling the cultivation of the fertile areas on the wet clay and the second was the development of the railway line connecting the region to London (Everrit, 1986). Land was also converted into one of the fruit and hop growing districts of the country, however these new orchards and hop gardens were placed into the ancient field patterns so did not generate a new agricultural landscape (Everrit, 1986). The agrarian structure of Kent was and continues to be shaped by regional divisions with historical characteristics and features imprinted in many parts of the countryside today, for example hedgerows and ancient trees. Therefore, Kent provided an excellent opportunity to study hedgerows and farmland trees which had aerial images from the 1940s, 1960s and present day using Google Earth as a source.

A similar sub-division is adopted as the basis of the Historical Atlas of Kent (Lawson and Killingray, 2004). The term 'physiographic region' is used and these regions are very similar to Everitt's ‘pays’, and are based on the geology and related relief features of Kent (Young, 2004). This research focuses on two of these physiographic regions in Kent, 'The Downs' and the 'Low Weald’ (see figure 3.2, p.24). These two physiographic regions were chosen to gather data from for this project because they provide contrasting landscape characteristics based on both physical geography and cultural development and are two distinctive landscape units within Kent.

The Landscape Assessment is a landscape character study of Kent used by Kent County Council to form strategies involving planning and land management (Babtie, 2004). This landscape assessment is used to ensure Kent’s landscape distinctiveness and links with its historical history is continued while accommodating changes. The landscape assessment and landscape characterisation is an important tool for landscape conservation and countryside planning policy (Babtie, 2004). The landscape assessment report uses similar subdivisions to describe Kent like Everitt (1986) and Young (2004), which include the Kent Downs and the Low Weald regions which feature in this study.

The Kent Downs natural and cultural characteristics have largely been controlled by the physical environment and its underlying geology. The geology of the Kent Downs determines the nature of this landscape and is made up of folded and undulating chalk, gault clay, greensand and ragstone. Large areas of the Downs are overlaid by layers of clay with flints; this significantly reduces the drainage on the dip slopes of the chalk (Young, 2004). With porous chalk and greensand, the Kent Downs can be considered a reasonably dry landscape because water infiltrates through the bedrock. Dry valleys cut into the dip slopes and scarp along the North Downs and are characterised as being the areas relief feature (Young, 2004). The Kent Downs is characterised by dispersed settlements in high densities (English Heritage and Kent Downs AONB, 2012). Early settlements developed on the lower scarp slopes around nearby water sources from spring lines while medieval settlers settled along existing road networks. The landscape characteristic of the Kent Downs is primarily a farmed one evolving through the centuries of human activity (Kent Downs Area of Outstanding Natural Beauty, 2015). However in comparison the chalk geology provided less fertile soils then the clay and lacking cultivation skills medieval people considered this area poor for agricultural potential (Everitt, 1986). The lack of fertile soil and cultivation problems meant the land was used as common pasture pre historically (Everitt, 1986); but with the development of technology and machinery the land has been used for the production of agriculture and are associated with hop gardens and orchards (Kent Downs Area of Outstanding Natural Beauty, 2015).

The Kent Downs was designated as an 'Area of Outstanding Natural Beauty' (Kent Downs Area of Outstanding Natural Beauty, 2015) in 1968. Economic and social needs are required to be consistent with the area's agricultural needs, forestry and the conservation of the area's natural beauty. Today over seventy percent of land in this area is farmed so the decisions that farmers and land owners make directly influences the landscape (Kent Downs Area of Outstanding Natural Beauty, 2015). Support and advice about Common Agricultural Policies and Environmental Stewardships is offered to farmers and landowners by the Kent Downs Area of Outstanding Natural Beauty Unit (Kent Downs Area of Outstanding Natural Beauty, 2015).

The Low Weald comprises of an undulating vale landscape, making up the ill drained heavily soiled Weald clays (Everitt, 1986). Processes of erosion have exposed this area with the weald clays intermixed with resistant bands of sandstones and limestones. Prehistoric communities were deterred by the thick woodland that covered the Low Weald so little attempt was made to clear the land as the heavy wet soils proved poor for agriculture. The land was later exploited for iron ores and sands in the sixteenth century (Everitt, 1986). The area today is characterised by a dispersed high density of settlement on a largely medieval landscape.

The Low Weald is drained by numerous streams carving narrow valleys into the Weald clay which are important to the structure and ecological character of the area. The presence of both arable and pasture farmland is reflected by the well-drained land with the arable fields being generally smaller in size (South Downs Integrated Landscape Character Assessment, 2011). The boundaries of these fields are defined by woodland edges and generally dense well developed hedgerows; however, because of field expansion there have been observed changes in the last seventy years regarding hedgerow loss (South Downs Integrated Landscape Character Assessment, 2011). Hedgerow trees in this region are mainly oak and also occur as individual features within fields. These landscape features provide links to the predominantly larger woodland features nearby.

The Low Weald can be characterised as a wooded agricultural landscape, with many ancient woodland sites being designated SNCI sites because of their ecological importance involving lichens and invertebrate communities (South Downs Integrated Landscape Character Assessment, 2011). Agricultural management in the Low Weald has been largely driven by Common Agricultural Policies and the world market. Pressures to provide for the world market and keep up with the demand for food production could see a continued increase in field size and hedgerow loss in the Low Weald area where the soils are more fertile and well drained (South Downs Integrated Landscape Character Assessment, 2011).

These two contrasting regions should see a difference in the lengths of hedgerows and number of trees on the farmland. Previous studies have shown that the geology of a physiographic region can be an influencing factor concerning the number and occurrence of microhabitats that are present on fallen trees, with trees on clay producing more than those on chalk (Dicker, 2015). It would then be interesting to investigate if the geology of these two physiographic regions could be an influencing factor concerning the production of microhabitats on standing trees in a farmland system.

2.5: Previous Research

Aerial photography is an important method to apply and interpret when analysing landscape changes and is an important method for monitoring the environment (Thomson, *et al.,* 2007). Aerial photography was introduced in the 1860s during the American Civil War and photogrammetry was used extensively by the UK during the First World War which enabled battle maps to be produced. In the early 1940s nearly the whole of Great Britain had been photographed (Thomson, *et al.,* 2007). With human activities influencing Britain's changing landscape using aerial photography to access the historical changes can provide a foundation for future monitoring (Thomson, *et al.,* 2007). Historical photographs when compared with recent photography of a landscape can provide a valuable source of information on when a particular landscape went through a change and if a certain feature went into decline or increased.

The BIOPRESS is a European Union project which studied the changes over the last half century in land uses and cover and their effect on biodiversity and the environment (Thomson, *et al.,* 2007). Five thirty by thirty kilometre sample windows were sampled across Europe based on Natura 2000 sites, with eight smaller fifteen by two kilometre transects within those windows. For the larger sample windows aerial photography from the 1950s and 1990 was analysed and compared. For the more detailed smaller transects aerial photography from 1950, 1990 and 2000 was analysed and compared. The results from this study highlighted that the Natura 2000 sites changed less than surrounding environments so are fairly protected. This study also highlights how aerial photography can be a consistent and reliable method for monitoring land cover over a period of time (Thomson, *et al.,* 2007).

A nationwide study conducted in the UK found that bat activity was positively associated with hedgerows and trees (Boughey, *et al.,* 2011). The importance of hedgerow trees for the bats was also considered in Boughey, *et al.,* (2011) research and showed that hedgerow trees can benefit bat populations by providing shelter from predators and ecological corridors. The study identified that agri-environmental schemes aimed towards hedgerow management can improve the biodiversity of a landscape by considering the retention of hedgerow trees (Boughey, *et al.,* 2011)

Various studies have identified that older trees can provide unique specialised microhabitats for a variety of species which depend on them for shelter, nesting and food (Regnery, *et al.,* 2013). Nine different microhabitats including cavities, cracks, fungi, ivy, conks and deadwood were studied by Regnery, *et al.,* (2013) to investigate the relationship between the microhabitats and the tree characteristics. They concluded that there was a positive relationship between the trees diameter and the richness of microhabitats and those larger trees generally had more microhabitats then younger trees (Regnery, *et al.,* 2013). Formation of these specialised microhabitats such as cavities generally occur in dead or dying trees (Holloway, *et al.,* 2007). These trees commonly get removed from the environment either for safety reasons or because of the lack of understanding about the habitats they create. This has resulted in the decline in the decaying wood habitat causing organisms of conservation importance to decline and become isolated to areas that have this habitat (Cowan, 2003). Tree hollows are another important microhabitat that many mammals, birds and invertebrates are dependent on. But, with the decline of veteran and ancient trees in agricultural and forest areas this microhabitat and its dependent species are under threat (Ranius, *et al.,* 2009). The results from Ranius, *et al.,* (2009) showed that fifty percent of the trees aged between two hundred and three hundred years old had hollows, with all the trees aged four hundred and over, all having hollows. Less than one percent of trees aged one hundred or younger had rot hollows. Research by Wormington, *et al.,* (2003) also highlighted that the average age that trees began to form hollows was between one hundred and eighty seven and three hundred and twenty four years (Wormington, *et al.,* 2003). These researches therefore indicate the need to maintain and sustain ancient and veteran trees in all landscapes to produce these habitats.

Previous research studying microhabitats on forest trees by (Vuidot, *et al.,* 2011) studied the types of microhabitats and recorded their presence on one thousand two hundred and fifty two trees. They identified that forest management was unlikely to influence the amount of microhabitats present at tree level and it was mainly the characteristics of the tree which determined how many microhabitats it hosted. Winter and Moller, (2008) also looked at the microhabitats on five hundred and seventy one trees in managed, recently unmanaged and unmanaged for over one hundred years of . They identified that the diversity and number of microhabitats was higher in mature stands but over eighty percent of the trees studied regardless of being managed or unmanaged had only a single microhabitat (Winter and Moller, 2008).

Research and knowledge on these specialised microhabitats and the trees which can provide them is crucial to conservation and ecological formation of certain species (Fritz and Heilmann-Clausen, 2010). As these studies were conducted in large forested areas, this research is going to study hedgerow and farmland trees to highlight if any produce these specialised microhabitats. Studying the landscape change will also provide an indicator as to approximately how long those features have been available.

Similar research to this study has been conducted on the South Downs National Park, Sussex, UK by (Burnside, et al., 2002). They studied the landscape changes that occurred between 1971 and 1991 on the South Downs. Agriculture is the dominate land use and since World War Two the landscape of the South Downs has changed because of agricultural activities. The methods are similar to those chosen for this study. The research methods used by Burnside, *et al.,* (2002) involved the use of aerial photography to evaluate the land use over time. A GIS database was also created to identify what areas of land remained in the same land category and which had been changed into another, for example, grassland to arable. This research reflected the amount of change caused by the intensification of agriculture.

These studies provide information to consider when conducting this research. Even though this research is looking at hedgerows and farmland trees the concept that the same species of tree is likely to have the same amount of microhabitats whatever the management is important to consider in relation to farm management and creation of specialised microhabitats.

3. Methodology

This project focused on how much the agricultural industry has had an impact on the density of hedgerows and farmland trees as part of the landscape, with two contrasting physiographic regions in Kent providing the setting for this research. The main data source was aerial photography/imagery, supplemented by map data and field work. Kent was chosen, in part, because aerial imagery was available for key periods from the 1940s onwards. The second part of the project that was investigated was the impact that hedge management practices were having on farmland trees and if they were affecting the number of specialised microhabitats present on the trees.

3.1: Site Description and Landscape Characteristics

Kent has been a landscape of enclosure since the eighteenth and nineteenth century, with hedgerows and farmland trees forming an important component of the landscape (Rackham, 1986). Historically, Kent has been divided into the East and West, but the influence on settlement was predominately caused by the North South divisions relating to the geology which provide highly contrasted areas of countryside (Everitt, 1986). The development of Kent has been moulded by the economy and environment because of the contrasting geological conditions and structure, these soil types vary more than any other county in England of similar size (Garrad, 1954). The geological structure of Kent has therefore had a historical influence on the settlement of populations, development of roads and patterns of farming (Everitt, 1986).

The agrarian structure of Kent was and continues to be shaped by regional divisions, with historical characteristics and features imprinted in many parts of the countryside today, for example hedgerows and ancient trees. The uniqueness of Kent’s geological structure meant Kent provided an excellent opportunity to study hedgerows and farmland trees. This research focuses on two physiographic regions found in Kent, 'The Downs' and the 'Low Weald’. These two physiographic regions were chosen to gather data from for this project because they provide contrasting landscape characteristics based on both physical geography and cultural development and are two distinctive landscape units within Kent.

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Today The Kent Downs is a designated Area of Outstanding Natural Beauty with a purpose to enhance and conserve the natural beauty of the landscape (Kent Downs Area of Outstanding Natural Beauty, 2015). Economic and social needs are required to be consistent with the area's agricultural needs, forestry and the conservation of the area's natural beauty. Today over seventy percent of land in this area is farmed so the decisions that farmers and land owners make directly influences the landscape (Kent Downs Area of Outstanding Natural Beauty, 2015). Support and advice about Common Agricultural Policies and Environmental Stewardships is offered to farmers and landowners by the Kent Downs Area of Outstanding Natural Beauty Unit (Kent Downs Area of Outstanding Natural Beauty, 2015).

The Low Weald, by comparison is comprised of an undulating vale landscape, making up the ill drained heavily soiled Weald clays (Everitt, 1986). Processes of erosion have exposed this area with the weald clays intermixed with resistant bands of sandstones and limestones. Prehistoric communities were deterred by the thick woodland that covered the Low Weald so little attempt was made to clear the land as the heavy wet soils proved poor for agriculture. The land was later exploited for iron ores and sands in the sixteenth century (Everitt, 1986). The area today is characterised by a dispersed high density of settlement on a largely medieval landscape.

The Low Weald is drained by numerous streams carving narrow valleys into the Weald clay which are important to the structure and ecological character of the area. The presence of both arable and pasture farmland is reflected by the well-drained land with the arable fields being generally smaller in size (South Downs Integrated Landscape Character Assessment, 2011). The boundaries of these fields are defined by woodland edges and generally dense well developed hedgerows; however, because of field expansion there have been observed changes in the last seventy years regarding hedgerow loss (South Downs Integrated Landscape Character Assessment, 2011). Hedgerow trees in this region are mainly oak and also occur as individual features within fields. These landscape features provide links to the predominantly larger woodland features nearby.

The Low Weald can be characterised as a wooded agricultural landscape, with many ancient woodland sites being designated SNCI sites because of their ecological importance involving lichens and invertebrate communities (South Downs Integrated Landscape Character Assessment, 2011). Agricultural management in the Low Weald has been largely driven by Common Agricultural Policies and the world market. Pressures to provide for the world market and keep up with the demand for food production could see a continued increase in field size and hedgerow loss in the Low Weald area where the soils are more fertile and well drained (South Downs Integrated Landscape Character Assessment, 2011).

These two contrasting regions should see a difference in the lengths of hedgerows and number of trees on and surrounding farmland because of the different geological structures and the way the land has been used over time. Previous studies have shown that the geology of a physiographic region can be an influencing factor concerning the number and occurrence of microhabitats that are present on fallen trees; with those fallen on clay producing more than those on chalk (Dicker, 2015). The results from that study can then be compared with the data collected from this project to consider if the geology of the two chosen physiographic regions could be an influencing factor concerning the production of microhabitats on standing trees in a farmland system and if there are any similarities with the results that can explain further reasons why these microhabitats are present or absent.

3.2: Aerial Photography

Aerial photography provides an opportunity to undertake a historical study on the changing agricultural landscape of Kent. It was deemed the most accurate and accessible method to collect data involving the changes of the agricultural landscape over a period of time over a large area of land. The air photographs were sampled to provide data on the density of hedgerows (length per square kilometre) and their quality (e.g, presence of gaps), as well as number of hedgerow trees and trees on open farmland per square kilometre.

Previous studies of landscape change have shown that hedges and farmland trees have been affected by both policy and technological factors associated with transitions in UK farming, for example, in response to post-war agricultural policy and support mechanisms, or the UK's entry into the Common Agricultural Policy (CAP) of the EU. The availability of air photographic cover from 1946 onwards, for Kent, allows possible changes to be tracked across the whole post-war period to the present.

Historical aerial images of Kent, ranging from 1946 to 2015, are available via Google Earth. Aerial images from the time periods, 1946, 1960 and 2015 were selected as the years to analyse in the selected physiographic regions. The year 1946 provides a view of the landscape prior to the post-war 'productivist' drive, initiated by the 1947 Agricultural Act and the guarantees of stability in rural areas provided by the 1947 Town and Country Planning Act. By 1960, UK farming had become heavily capitalised under government support and processes, such as field enlargement (and subsequent hedgerow loss) are evident in the country as a whole. 2015 represented landscape changes that occurred after the years of the intensification of agriculture and through the post intensification reform.

The imagery from 1946 and 1960 were black and white photos and had been uploaded onto Google Earth by the Kent County Council and Image NASA. These images however, did not indicate the month when the photos were taken, but it could be assumed that they were taken in the summer months because trees had full dense crowns implying that they had not shed their leaves. 2015 was coloured digital imagery and was uploaded by Getmapping plc.

The months available for some of the imagery taken were in April, June and July. 1946 provided the most historic aerial image available on what Britain's agricultural landscape used to look like, with 2015 showing the most up to date image. 1960 was also chosen as an important year to examine as it was around the 1960s when the agricultural landscape went into decline and degradation. Time constraints meant that the analysis for 1990 could not be done in time for completion. It would however, be an interesting year to examine in future work, to observe if there was a larger or smaller decline or increase in farm features between 1960 and 1990 compared with between 1990 and 2015. This could then highlight if the Hedgerow Regulations Act and the introduction of agri-environmental schemes had the desired effect on increasing the length of Britain's hedgerows.

3.3: Data Selection

To select the sample sites for the aerial photography analysis various steps were conducted.

In ArcGIS 10.2.2, 2014, a geology map of Kent and a grid made up of two kilometre by two kilometre squares was overlaid on a satellite base map of Kent (see figure 3.1, p.38). This grid provided the foundation for selecting the sample squares. The grid was created to cover all of the physiographic areas within Kent, to allow for wider sampling should time have been available. Grid squares falling outside of the physiographic units were ignored for the purposes of this study.

Every square over the whole of Kent was analysed with landscape imagery being used from 2015. The criteria needed to be met for the acceptance of a square to go towards the data pool were as follows:

- Land had to make up the complete two kilometres by two kilometres square. For example, squares were rejected if parts of it extended into the sea or had two different geologies within.
- The square had to be made up predominantly of countryside. For example, squares were rejected if it contained over fifty percent of woodland, water bodies and/or built up areas.
- Other features that caused squares to be disregarded were if they had over fifty percent made up of manmade features, for example a quarry, reservoir or golf courses.

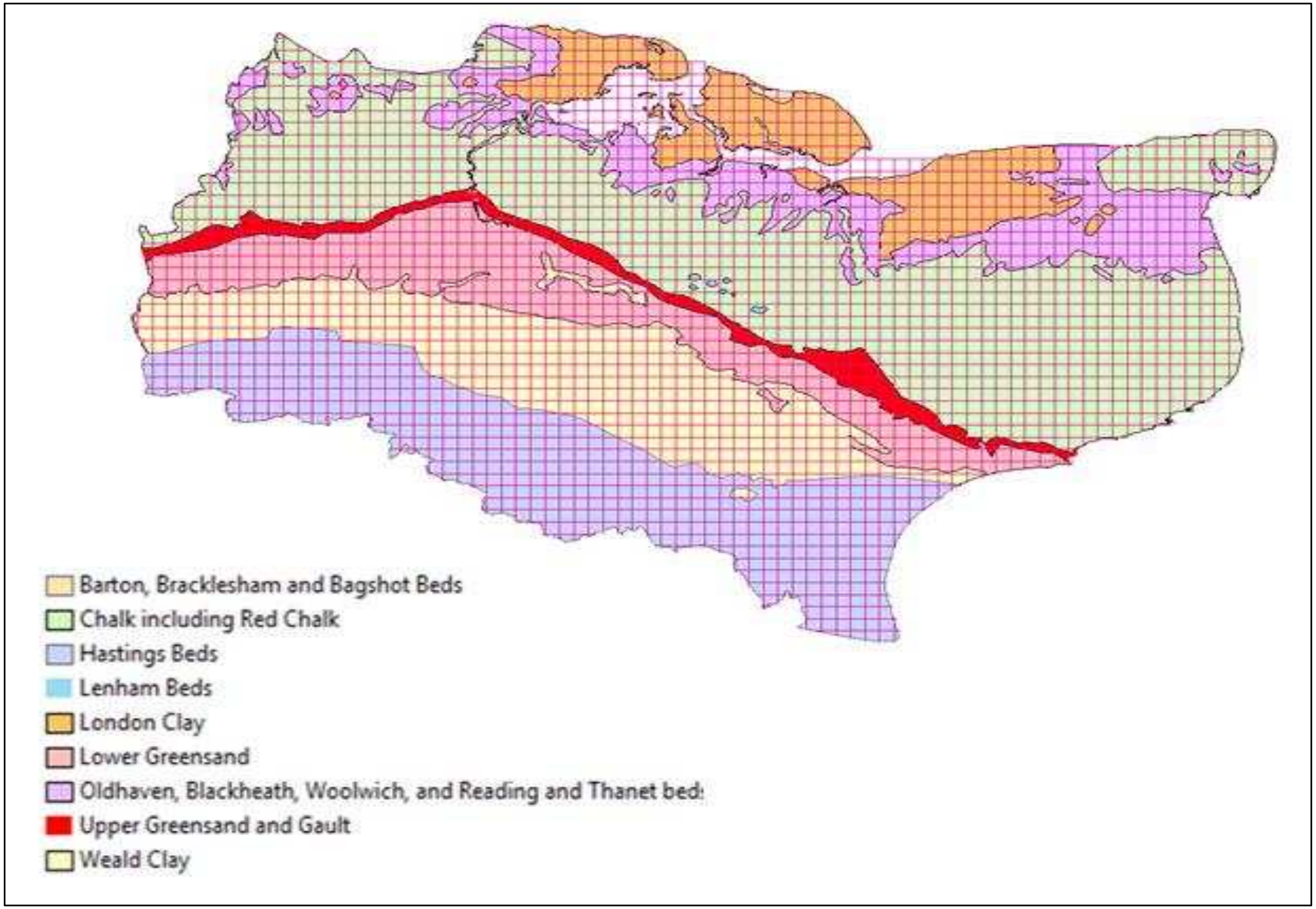


Figure 3.1: Geology map and grid over Kent

Source: DIGIMAPGB-625, British Geological Survey 1:625,000, (ed. 2007)

It was decided to use the 2015 imagery when accepting or rejecting potential sample squares rather than include areas which were made up of fields in 1946 or 1960 before they were developed on. This meant that the fields in use today were analysed to see if and how they had changed over time.

The decision to reject squares that were made up of over fifty percent woodland from the 2015 imagery was arguably down to the understanding that woodlands were more likely to stay a stable size over the years and would not offer a significant amount of data if accepted. From the 2015 imagery, squares made up of over fifty percent urban features were also rejected. This was because urban development within the countryside was present in the majority of sample squares observed, either on a large scale or a small scale; large scale being villages expanding into towns and on a small scale farms and houses extending their buildings and garden size. The British landscape has gone through various changes, be it natural or human induced. This research is examining the impact over time that the agriculture system has had on the countryside and its farmland features, caused by agricultural developments not urban development. If squares made up of mainly urban and woodland features had been selected to go towards the data set, fewer fields and countryside features would have been available to analyse. This would then have not produced the amount of data required for this research.

To ensure the whole of the Kent landscape was analysed, all squares in the area of Kent were either disregarded or accepted, with six hundred and ninety eight squares selected as potential sample plots (see figure 3.2, p.39). This meant that the data pool covered all the geologies in Kent and generated future sampling plots if required.

In the order of acceptance, each accepted square was given a systematic number so that a systematic sampling method could be conducted at a later stage. Time constraints meant that only two physiographic regions could be analysed, the Weald clay and Downs chalk. The accepted potential sample plots within these two areas were then analysed again using the time bar in Google Earth to assess if the quality of the aerial photography was adequate to analyse and extract data from. If part of an image for either 1946, 1960 or 2015 within the square were missing, i.e. parts of the photo were blocked black or white then that square was disregarded from the data pool (see figure 3.3, p.41). If an image was also blurry, hard to read or had various images overlapping each other, producing an unclear mosaic image, (see figure 3.4, p.41) then they were also disregarded. This was done to limit the number of errors that could be made when analysis took place

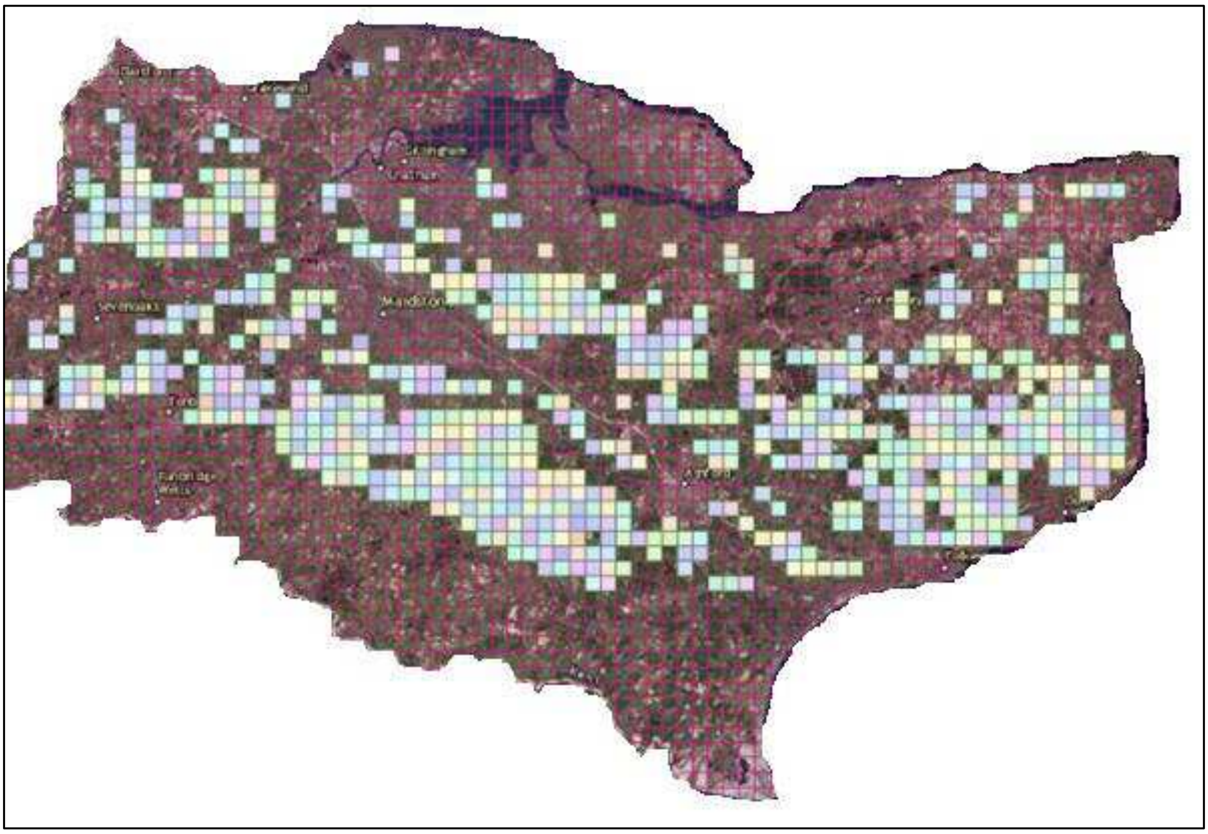


Figure 3.2: Potential sample plots

Figure 3.5 displays the six hundred and ninety eight squares selected as potential sample plots.

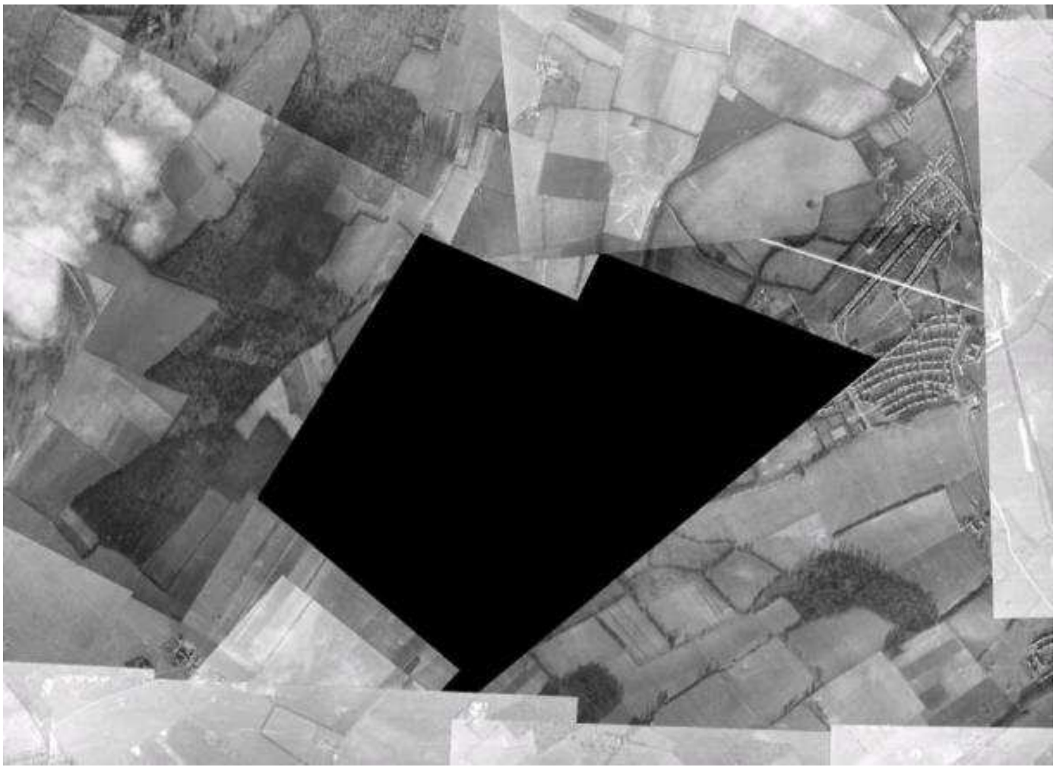


Figure 3.3: Example of a disregarded image

Figure 3.4: Example of a mosaic image

After the main data pool of accepted sample squares was completed, it was decided that thirty squares (Dixon and Leach, 1978) was a suitable number to analyse. Each of those thirty squares was analysed in 1946, 1960 and 2015, giving a sample size of ninety in each physiographic location and a total sample size of one hundred and eighty squares analysed.

The systematic sampling method (Dixon and Leach, 1978) was considered the quickest method to identify what squares from the data pool would be used for analysis in each physiographic region. The total number of potential sample plots for each physiographic region was divided by thirty to get an 'nth' number. Within the chalk section of Kent three hundred and forty three squares were selected as potential sample plots with two hundred and eleven within the clay landscape. When divided by thirty the 'nth' number or interval for the chalk was eleven point four and seven for the clay. All the potential samples squares had been given a numerical number, so every eleventh square in the chalk landscape was selected to go towards the main data set and every seventh for the clay (see figure 3.5).

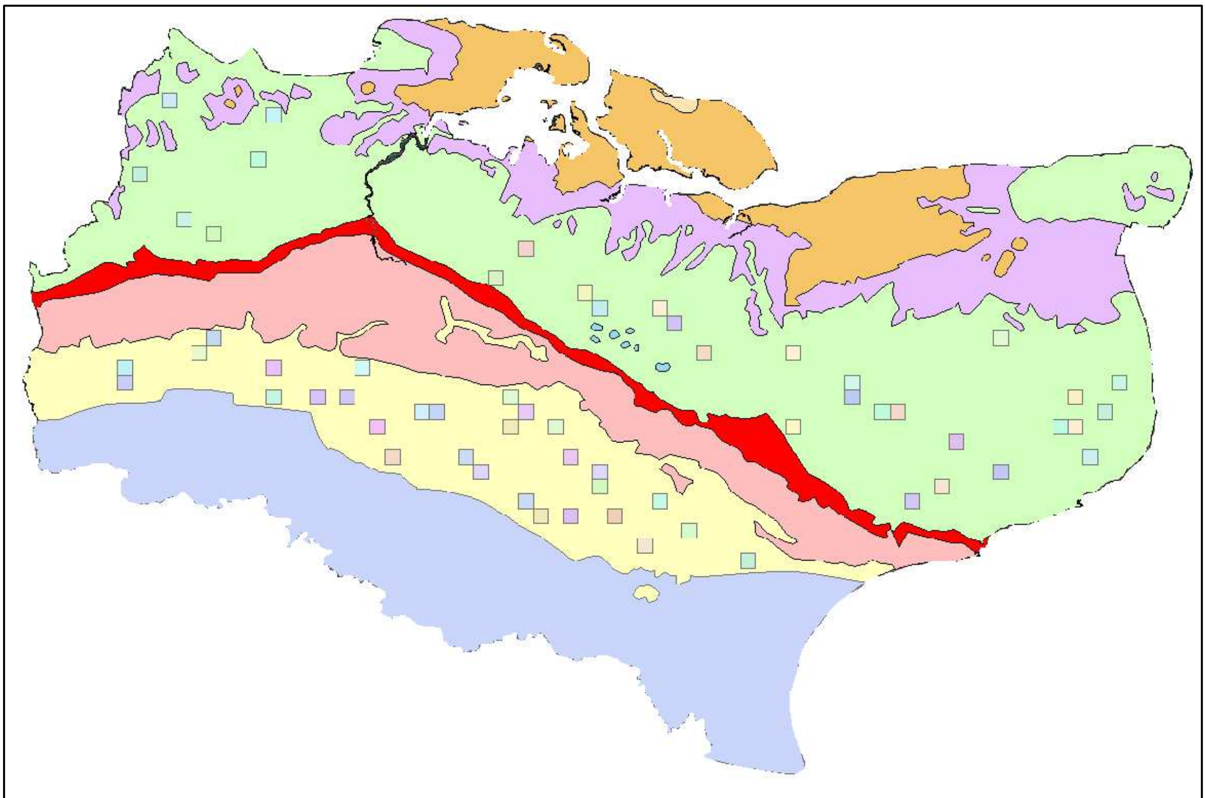


Figure 3.5.: Selected Sample Squares

The selected data squares were then exported out of ArcGIS and imported into Google Earth to enable digitisation of landscape features to occur. When the squares were imported into Google Earth an error occurred involving the length of the squares. Measuring two kilometres by two kilometres in ArcMap, the length then distorted to 1.25 kilometres by 1.25 kilometres in Google Earth. This distortion of the squares length on conversion was caused by the differing spatial references and map projections used in ArcGIS and Google Earth. The size of the squares making up the grid was only used as a foundation to ensure that the sample plots observed were the same size. As this did not affect what the research was examining the squares were kept as 1.25km by 1.25km because the data set was still consistent. Even though the conversion led to an error, it meant that the square kilometres of Kent's landscape examined were randomly selected at over forty six square kilometres.

Within each square certain variables were digitized on top of the photo image for each date, either via a line or a polygon (see figure 3.6 and 3.7, p.44). These features included:

- 90-100% Hedged Boundary
- 50-90% Hedged Boundary (If lengths of a hedged boundary had gaps in but the hedge was the majority of the boundary)
- 1-50% Hedged Boundary (A hedged boundary with significant length of gaps)
- Other Boundary (Where there was no boundary but ground markings, or wood or wired fences)
- Tree Boundary (Boundary made up of a line of trees)
- Isolated Individual Trees (Number of lone standing trees on agricultural land were counted)
- Trees in Hedgerows (Number of trees within hedgerows surrounding fields were counted)
- Trees in Boundary (Number of trees on a boundary made up of a line of trees)
- Areas of Wood/ shrubland
- Orchards

Figure 3.6: Digitized Square Example

- Pink Line – 90-100% Hedged Boundary
- Yellow Line – 50-90% Hedged
- Orange Line – 1-50% Hedged
- Purple Line – Other Boundary (Wired, wooden or grass verge)
- Green Line – Tree Boundary
- Green Block – Woodland/ Shrubland
- Pink Block - Orchard

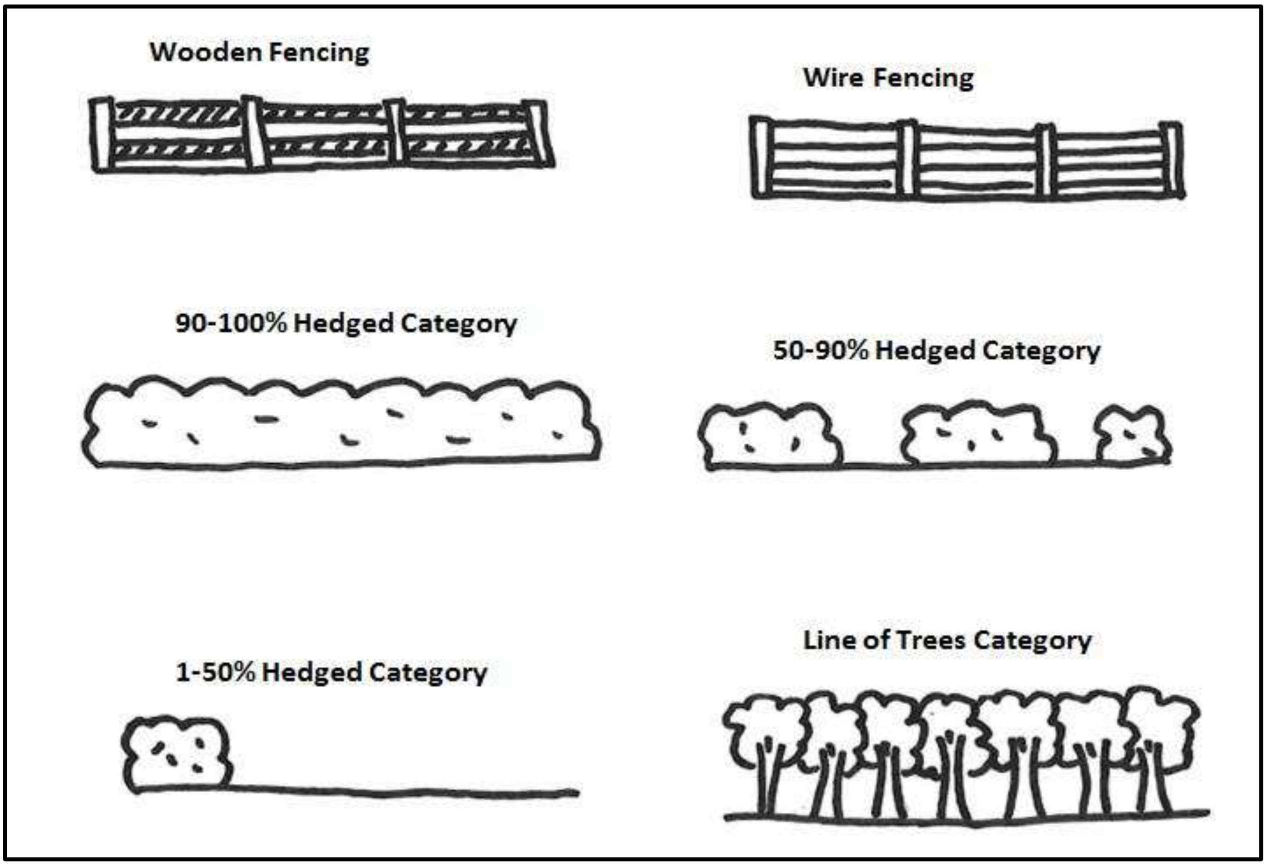


Figure 3.7: Six visual representations of the main boundary categories analysed

The three hedgerow categories (90-100%, 50-90% and 1-50% hedged) were chosen to calculate the approximate length of each type of hedged boundary. This then highlighted how much hedgerow boundary had been lost or gained since 1946 and identified the hedgerows potential condition. Calculating the length of other boundaries also enabled a comparison to be made as to whether boundaries that are made of, for example fences, are more popular as a boundary material compared with hedgerows. Measuring these variables over time could also show if hedgerows were managed through the years or left to grow to become either 'gappy' hedgerows or tree boundaries.

The number of lone individual trees, trees in hedgerows and trees forming a line were also important variables to count, to highlight if there has been an increase or decrease in the number of trees on farmland in Kent. Further analysis could then question why some trees were removed in an area and question if it was because of agricultural change or other forms of development. Areas of wood/ shrubland and orchards were digitized as they both provide network corridors between different landscape features.

The quality of the aerial imagery for 1946, 1960 and 2015 varied with each sample square. Some of the older images were blurred, faded or had scratches and stamp markings on top. Others were difficult to interpret where two or more photos overlapped as part of the mosaic format. This made the analysis difficult and took more time to distinguish the landscape features. To be certain that correct identifications were being made, the aerial images from 1946, 1960 and 2015 were compared against each other. They were also compared against Ordnance Survey maps (1:25,000) to confirm the presence of field boundaries for key dates. Each sample square took between two and six hours to analyse depending on both the number of features and image quality within the sample plot.

The aerial images for 1946 and 1960 were black and white; therefore identifying what was a hedge was more difficult and time consuming for those years than 2015. To ensure the data digitized was consistent, hedgerows were identified as thick dark uniformed lines along the edge of a field. Trees were identified using the shadow effect in the 1946 and 1960 images. If a feature in a field had a shadow effect then that indicated that the feature was a particular size to create that shadow. The shadow effect was also used for trees in hedgerows because the crown structure of a tree had a larger width then the hedge it was in.

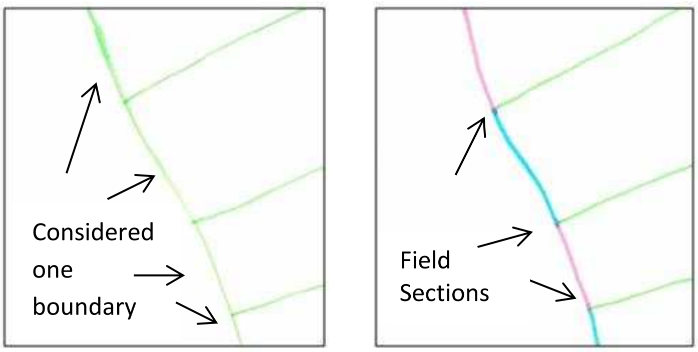
When the digitization of these squares was completed in Google Earth, they were saved and imported back into ArcGIS where the length and/or area of each digitized variable were calculated. Once the digitized features were in ArcGIS a new data field for each individual feature mapped (i.e, woodland and the different hedgerow length categories) within every square analysed was created. The 'Calculate Geometry' function was then used to calculate the area of woodland and the length of each hedgerow category present within each sample square. The 'Statistics' tool was then used on the calculated areas and lengths to calculate the total for each digitized feature within each square. For each year, the length for each feature was added together to create a grand total to be used for the statistical analysis and graph production. For example, the thirty different lengths of 90-100% hedged boundary calculated in the thirty 1946 images analysed, were added together to give an overall length for that year. This was then repeated for 1960 and 2015. By creating a grand total for each feature for each year meant it could then be clearly identified if hedgerows and number of trees within the farmland system had declined or decreased over time.

3.4: Fieldwork

To assess the credibility and accuracy of the digitization and identification process of the hedgerow percentage, lines of tree, hedgerow trees and individual lone tree categories for the computer based data collection; digitized squares were taken into the field to evaluate its accuracy. When in the field, a boundary could easily be identified and then compared with the category it was originally assigned when digitized, to identify if what was being characterised in the field was the same as what was being classified on the computer. This then gave an insight as to how accurate the data collected using the aerial photography had been. For example, three digitized sample squares were taken into the field, the correct and wrong boundaries identified were then totalled to enable the percentage sum to be conducted: ***Wrong/Totalx100= Error Percentage.*** For the first square, twenty seven boundaries identified were correct while three were wrong, the second had twenty five right and four wrong and the third had thirty one right and three wrong. The percentage error therefore for the first square was ten percent, the second was thirteen percent and the third was eight point eight percent. The process of identification was then revised so the overall error would be lower still. For example, there were several sections where a field boundary was considered too long and ran along several fields. It was agreed that each field should be counted as one; therefore a boundary of a field was identified to where its edge met another. This reduced the chances of observing two different boundary management practices, for example, a field that was used for pasture would require a stock-proof hedge, while an adjacent field (arable) might not require a physical boundary and a hedge might be left 'gappy' or even removed. This would then remove the error of categorizing a boundary as 50-90% when it was actually made up of 90-100% for one section and 1-50% for the other (see figure 3.8).

<u>Revised Process of Boundary Identification</u>

1a) 1b)



1a). Before fieldwork was conducted a boundary running along several fields was classified as one boundary.

1b). After fieldwork was conducted it was decided that a boundary should be classified until it meets a point connecting it to another boundary.

Figure 3.8: Revised Process of Boundary Identification.

1a). Represents a boundary running along one large field but being intersected by other boundaries for other fields. Originally, as the four sections of the boundary were running along the same field, they were categorized as one boundary category.

1b). Represents the same boundary as 1a but highlights the four sections of individual boundary within that boundary which end and start when a boundary connects with another. Each pink or blue line could therefore have a different boundary categorization.

A small pilot survey which formed part of the main fieldwork data set was conducted in East Sussex on the Ashdown Beds (Booth, 2005) at Fairlight close to the town Hastings in November 2015. This was conducted to assess the availability and difficulties that could arise when collecting the tree and microhabitat data for the second part of this research (see appendix 2).

Aerial images from Getmapping plc, Kent County Council and Image NASA) available on Google Earth were used to identify farm boundaries with hedgerows, hedgerow trees and lone trees in East Sussex which could be visited to conduct the analysis of the trees. Those boundaries were then compared with an Ordnance Survey map to ensure that there was a public right of way. Time constraints meant using public footpaths was the quickest method to gain access to the trees on the boundary of farmland. It was only when walking along the selected routes when the availability and accessibility of the trees was identified.

A typology was used to record a variety of features that can provide valuable microhabitats for a range of organisms (e.g. rot hollows used as insect and bird nesting sites). This typology was adapted from Vuidot, *et al.,* (2011) and Winter and Möller, (2008). Key variables measured included the girth of the trunk and the approximate height of the tree; other variables were recorded as either present or absence via field observations. Photographs were also taken of each tree and any of the characteristics present to act as a visual representation for when it came to analysing the data at a later stage.

Tree Number	More than 50% Crown Broken	Cavity String	Sap Flow
Date	Breakout/ Tear out Wound	Deep Stem Cavity	% Ivy
Time	Splintered Subsidiary Branch	Crack	Broken/Cut Branches
Species	Compression Fork Split	Mould/ Water/Bark Pocket	Dead Wood
Girth	Conk of Fungi	Debarked Area	Lichens, Moss, Fungi
Estimated Height	Rot Hole Cavity	Canker	Invertebrates
Estimated Height of Clearance	Occluding Wound	Witch Broom	Birds' Nests/Holes
Less than 50% Crown Broken	Woodpecker Cavity	Epicormic Growth	Other

Table 3.1: Typology of Microhabitats

Table 3.1 is a typology adapted from Vuidot, *et al.,* (2011) and Winter and Möller, (2008) of a variety of features that can provide valuable precursors for the production of microhabitats. This typology was taken into the field to analyse and record the microhabitats present or absent on the trees accessible to observe.

The fieldwork aspect for this project involved visiting a number of the sample squares to analyse and record the microhabitats present or absent on the trees. Selected squares were then cross referenced with an Ordnance Survey map using Digimap to locate the public right of way footpaths. Some public footpaths followed the edge of a field boundary whereas others cut through the middle of fields. Therefore, footpaths that were considered to have potential study features alongside were followed. A digitized image of the sample square was also taken into the field to check the accuracy of the identification process of the landscape features on the computer and to check that the identified image from the computer was that in the field. Thirty trees to observe and record data on in each physiographic region;-sixty in total, was chosen as the minimum number to analyse. They could all be studied in one square or various squares if required. A smaller sample size for this part of the data collection was chosen because of the lack of access and public footpaths in the sample squares, making it hard to find accessible trees to study.

3.5: Statistical Analysis

Two sample t-tests (pp. 69-79) were conducted on key data to test if there was a statistically significant difference in the length of hedgerows between 1946 and 1960 and 1960 and 2015 on both physiographic regions. A two sample t-test was also conducted to test if there was a statistically significant difference in the number of farmland trees between 1946 and 1960 and 1960 and 2015 on both physiographic regions The statistical analysis was conducted to test the interaction between the two factors; - year and geology, to identify if the changes were different over time between the physiographic regions and to question why particular landscapes were seeing larger increases or decreases compared to the other.

3.6: Future Research

Aerial photography was the appropriate method to collect the data for this project; however some of the images available lacked visual quality, especially the 1940s. This made it harder to identify certain features within an image. The quality of the aerial photography was also dependent on the weather conditions and the time of year that the photo was taken which could skew the identification process. For example, some images had cloud obscuring ground features. Even for the most recent images problems still arose when the images had been taken possibly in the autumn or winter months. As most of the imagery did not have a specific time or date available this theory was assumed because the trees had lost their leaves (unless they were conifers) meaning on the satellite imagery a crown structure for a tree was not visible. To counteract the problem faced when landscape features were covered by other features like clouds, the square the image was in was removed from the data pool and another square selected.

There were also some instances in the present day imagery where it looked like a hedgerow on a boundary had been severely trimmed, making it harder to clarify if the hedgerow was still present or if it had been removed. To combat this identification issue the images were compared with the earlier and later photography dates available. If the hedgerow had been there in a different year before and after the image then it would be highly likely that the hedgerow had not been removed, this would be the same for trees. Differentiating between a very well-trimmed hedge and a grass strip for a boundary also needed comparisons between imagery dates to be made as well as identifying if a shadow effect was present. A grass strip would cause a difference in colour but would not produce any shadow effect because of the lack of height produced, whereas a trimmed hedge would still produce a small shadow effect because its height would be greater.

Within the time constraints of this study it was only possible to examine two physiographic regions at three time scales. The data available via Google Earth provides further opportunities to examine landscape changes for other dates, for example 1990, and to extend the study to other regions. This study also indicates that further work on the relationship between management techniques and tree microhabitats would be valuable. This could entail asking farmers to state what management practices they use on their hedgerows to analyse which practice produces the most precursors for the production of microhabitats on hedgerow trees. This could then provide a greater understanding on what practices are creating certain precursors to potentially enhance the production of microhabitats in the agricultural landscape. It could also highlight the positive influences that hedgerow management practices are having on the environment.

Access to sites to examine individual trees was constrained by the need to use public rights of way. It was not possible to seek permission to access other areas given the fact that ownership of land is not always easy to ascertain. Access was also constrained by the fact that not all public rights of way are kept clear of vegetation, for example brambles, and in some instances gates were locked blocking access to the footpath. Accessing the trees when in a hedge was also difficult for many instances as most trees were buried in the middle of a hedge either with a thick hedge, a ditch or brambles and nettles surrounding it, so accessing the trunk to measure the circumference for most of the trees observed was not possible. If more time was available ownership of land could be ascertained to ask farmers and landowners for permission to access their hedgerows and trees to observe and collect data from. Methods used to conduct hedgerow management would also be an important method to consider highlighting the main practices being used.

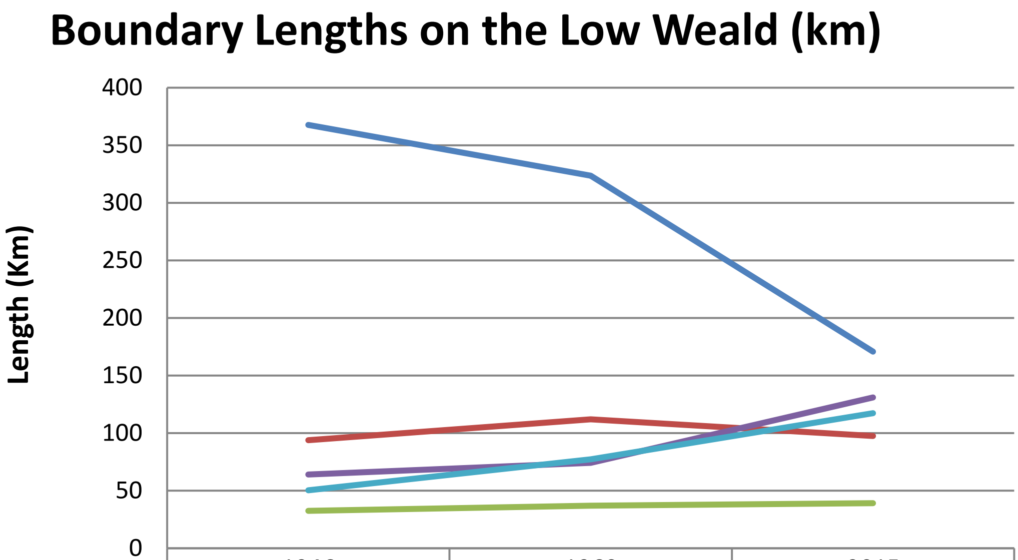
4. Analysis and Results

This section displays the results generated from the computer based aspect of this research. From these results it can be ascertained when the biggest changes to the length of hedgerows and number of farmland trees occurred and how much it differed between the two physiographic regions.

4.1: Boundary Lengths on the Low Weald and Downs

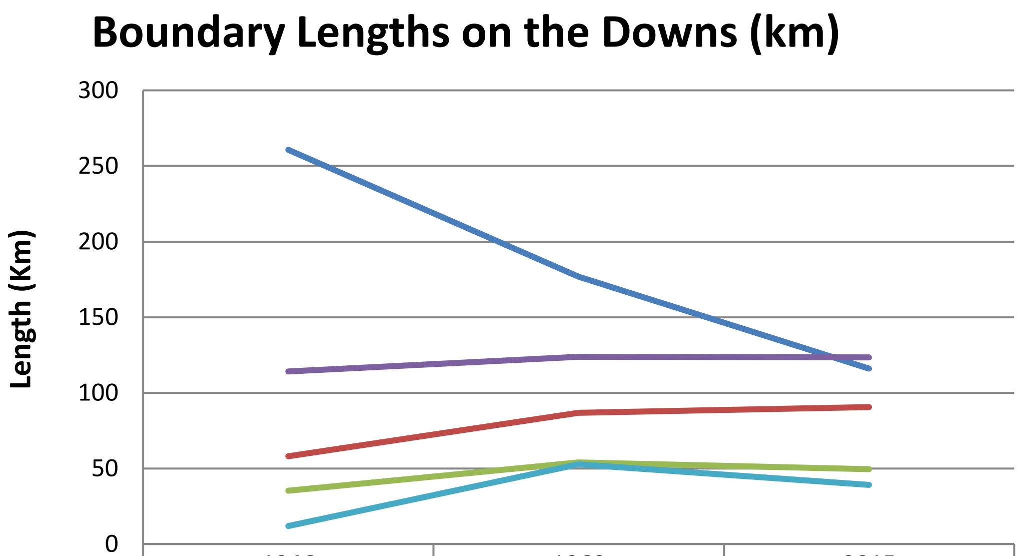
The total length calculated for each boundary category on the Low Weald (clay) and Downs (chalk) is highlighted in figure 4.1, 4.2 and4.3 (see pp.54-55) and table 4.1 and 4.2 (pp.56-57) to highlight the contrasting results.

The most dramatic result displayed concerns the 90-100% hedged category on the Low Weald and the Downs, where the lengths have decreased over fifty percent from 1946 to 2015.For the Low Weald the 90-100% hedged category is the only boundary to continuously decline from 1946 to 2015, whilst the tree boundary, 1-50% hedged and other boundary have continuously increased over the years. Like the Low Weald, the Downs also saw a continuous decline in the 90-100% hedged boundaries from 1946 to 2015, with the 50-90% category being the only boundary to see a continuous increase. The decline of 90-100% hedged boundaries for both regions can be explained by the concept that hedgerows have either been left to degrade causing gaps, unmanaged causing lines of trees, or been replaced for other boundary types.



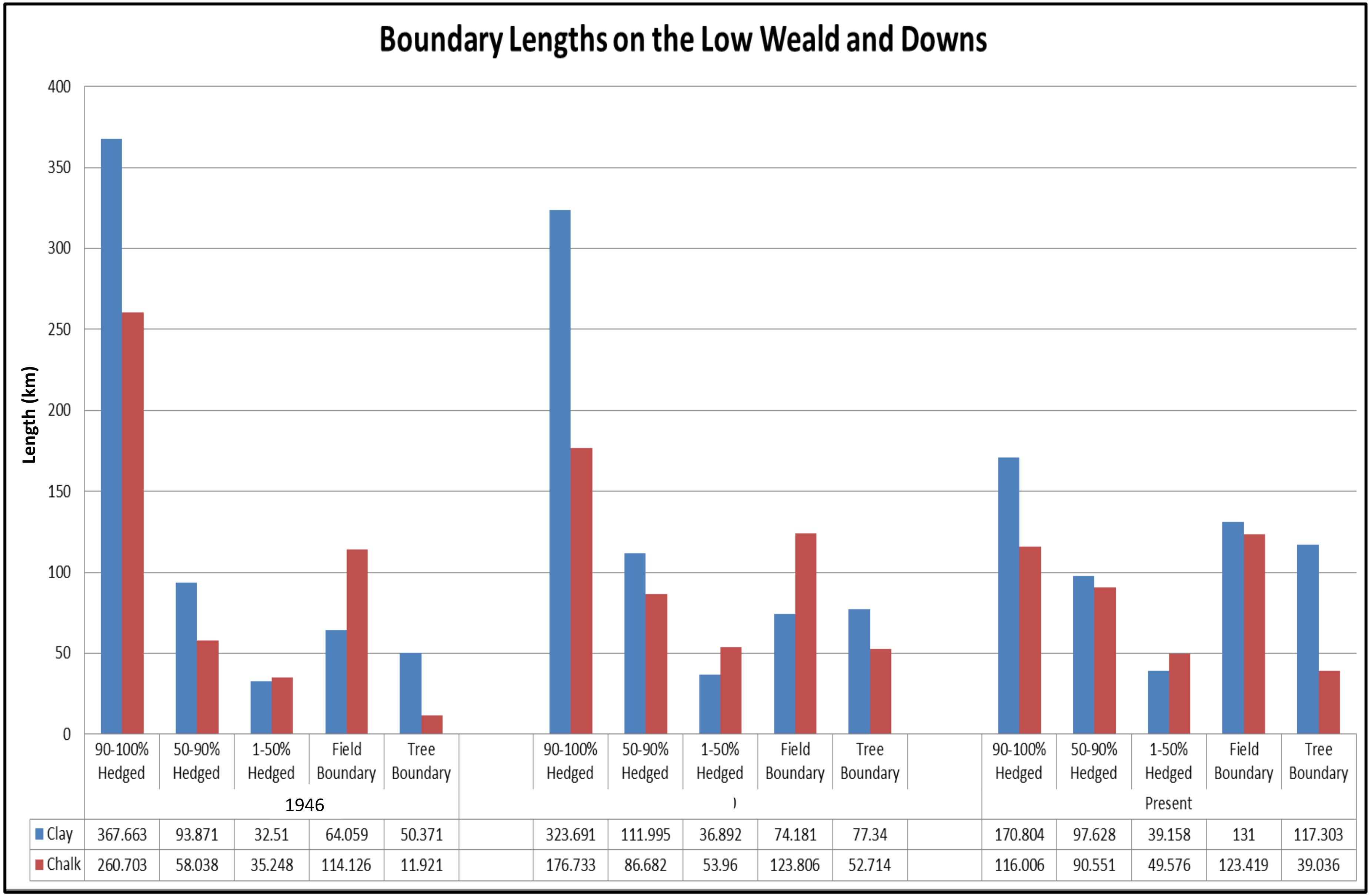
	1946	1960	2015
90-100% Hedged	367.663	323.691	170.804
50-90% Hedged	93.871	111.995	97.628
1-50% Hedged	32.51	36.892	39.158
Other Boundary	64.059	74.181	131
Tree Boundary	50.371	77.34	117.303

Figure 4.1: Boundary lengths on the Low Weald



	1946	1960	2015
90-100% Hedged	260.703	176.733	116.006
50-90% Hedged	58.038	86.682	90.551
1-50% Hedged	35.248	53.96	49.576
Other Boundary	114.126	123.806	123.419
Tree Boundary	11.921	52.714	39.036

Figure 4.2: Boundary lengths on the Downs



	90-100% Hedged	50-90% Hedged	1-50% Hedged	Field Boundary	Tree Boundary		90-100% Hedged	50-90% Hedged	1-50% Hedged	Field Boundary	Tree Boundary		90-100% Hedged	50-90% Hedged	1-50% Hedged	Field Boundary	Tree Boundary
	1946						)						Present				
Clay	367.663	93.871	32.51	64.059	50.371		323.691	111.995	36.892	74.181	77.34		170.804	97.628	39.158	131	117.303
Chalk	260.703	58.038	35.248	114.126	11.921		176.733	86.682	53.96	123.806	52.714		116.006	90.551	49.576	123.419	39.036

Figure: 4.3: Boundary lengths on the Low Weald and Downs

Clay 1946	Total Length (km)	Mean	Percentage	Length Per Sqkm2
90-100% Hedged	367.66	12.26	60.42	235.68
50-90% Hedged	93.87	3.13	15.43	60.17
1-50% Hedged	32.51	1.08	5.34	20.84
Tree Boundary	50.37	1.68	8.28	32.29
Other Boundary	64.06	2.14	10.53	41.06
Total Boundary Length	608.47	20.29	100	390.04
Total Hedged Length	494.04	16.47	81.19	316.69
Total Hedged/Tree Length	544.42	18.15	89.47	348.98
Clay 1960	Total Length (km)	Mean	Percentage	Length Per Sqkm2
90-100% Hedged	323.69	10.79	51.87	207.49
50-90% Hedged	111.99	3.73	17.94	71.79
1-50% Hedged	36.89	1.23	5.91	23.65
Tree Boundary	77.34	2.58	12.39	49.58
Other Boundary	74.18	2.47	11.89	47.55
Total Boundary Length	624.09	20.8	100	400.06
Total Hedged Length	472.58	15.75	75.72	302.93
Total Hedged/Tree Length	549.92	18.33	88.11	352.51
Clay 2015	Total Length (km)	Mean	Percentage	Length Per Sqkm2
90-100% Hedged	170.8	5.69	30.67	109.49
50-90% Hedged	97.63	3.25	17.53	62.58
1-50% Hedged	39.16	1.31	7.03	25.1
Tree Boundary	117.3	3.91	21.06	75.19
Other Boundary	131	4.36	23.52	83.97
Total Boundary Length	556.89	18.52	99.81	356.33
Total Hedged Length	307.59	10.25	55.23	197.17
Total Hedged/Tree Length	424.89	14.16	76.29	272.36

Table 4.1: Boundary Information for the Low Weald

Table 4.1 displays the boundaries total length, mean, percentage and length per square kilometre for the Low Weald region for 1946, 1960 and 2015.

Chalk 1946	Total Length (km)	Mean	Percentage	Length Per Sqkm2
90-100% Hedged	260.7	8.69	54.31	167.12
50-90% Hedged	58.04	1.93	12.09	37.21
1-50% Hedged	35.25	1.175	7.34	22.59
Tree Boundary	11.92	0.39	2.48	7.64
Other Boundary	114.13	3.8	23.78	73.16
Total Boundary Length	480.04	16	100	307.72
Total Hedged Length	353.99	11.79	73.74	226.92
Total Hedged/Tree Length	365.91	12.19	76.22	234.56
Chalk 1960	Total Length (km)	Mean	Percentage	Length Per Sqkm2
90-100% Hedged	176.73	5.89	35.78	113.29
50-90% Hedged	86.68	2.89	17.55	55.56
1-50% Hedged	53.96	1.79	10.93	34.59
Tree Boundary	52.71	1.76	10.67	33.79
Other Boundary	123.81	4.13	25.07	79.37
Total Boundary Length	493.89	16.46	100	316.59
Total Hedged Length	317.38	10.58	64.26	203.45
Total Hedged/Tree Length	370.09	12.34	74.93	237.24
Chalk 2015	Total Length (km)	Mean	Percentage	Length Per Sqkm2
90-100% Hedged	116.01	3.87	27.71	74.37
50-90% Hedged	90.55	3.02	21.63	58.04
1-50% Hedged	49.58	1.65	11.84	31.78
Tree Boundary	39.04	1.3	9.45	25.03
Other Boundary	123.42	4.11	29.48	79.12
Total Boundary Length	418.59	13.95	100.12	268.33
Total Hedged Length	256.13	8.54	61.18	164.19
Total Hedged/Tree Length	295.17	9.84	70.63	189.21

Table 4.2: Boundary Information for the Downs

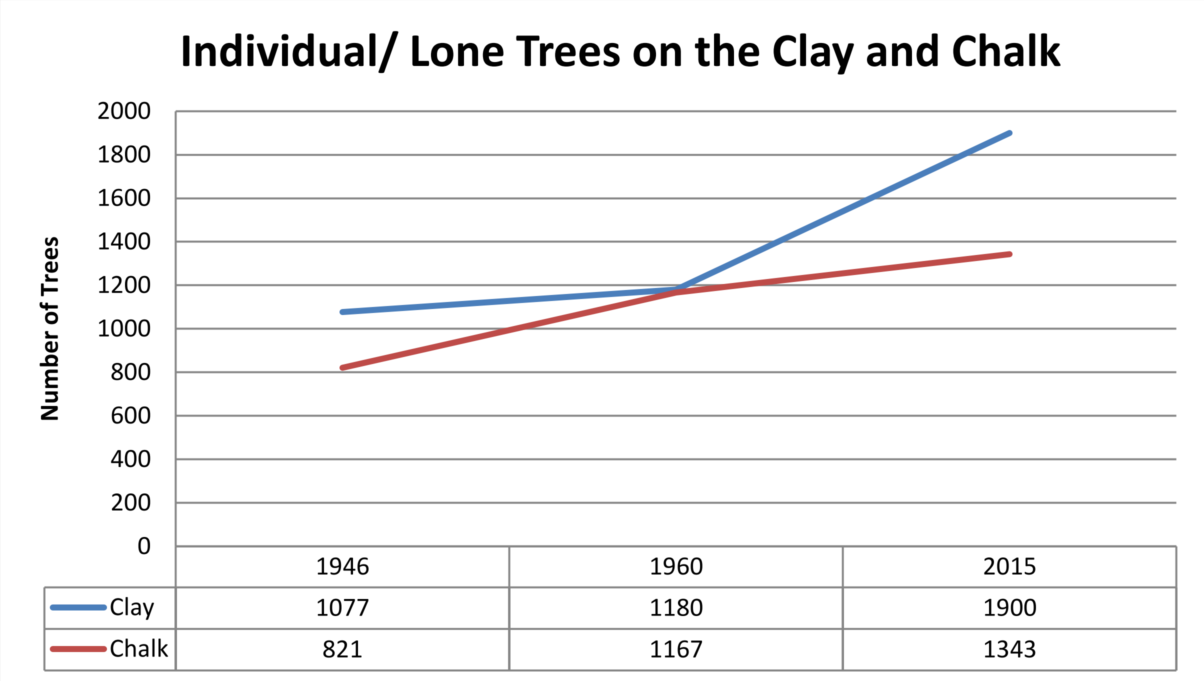
Table 4.2 displays the boundaries total length, mean, percentage and length per square kilometre for the Downs region for 1946, 1960 and 2015.

4.2: Quantity of Trees on the Low Weald and Downs

The total quantity of individual lone trees, hedgerow trees and lines of trees on the Low Weald and Downs are individually highlighted (pp.59-60) in figure 4.4, figure 4.5 and figure 4.6 and then combined in figure 4.7 to highlight the contrasting results.

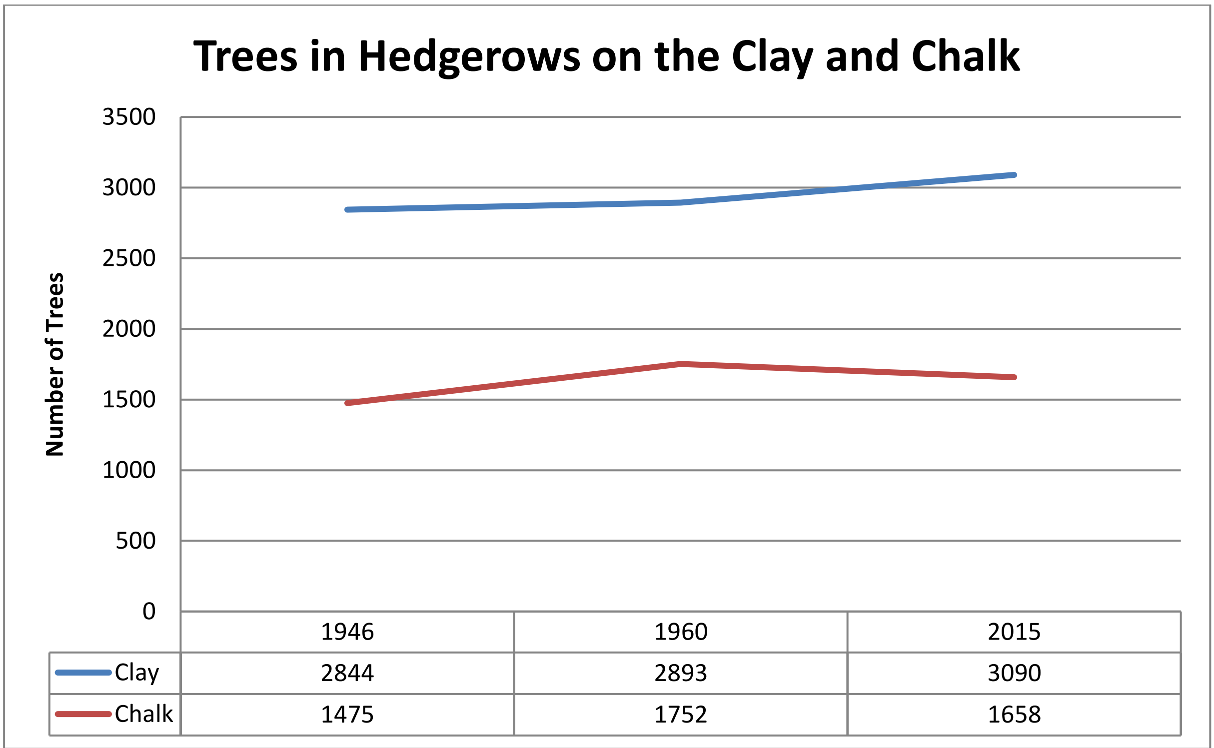
The number of individual lone trees calculated on both the Low Weald and Downs has increased continuously from 1946 to 2015; with the Low Weald having more in the landscape studied for each time period compared to the Downs landscape. The amount of trees growing in hedgerows has seen a slight increase on the Low Weald for all three time periods; whereas the number of trees in hedgerows on the Downs increased slightly between 1946 and 1960, but then decreased to just over the original number in 2015. The number of trees that formed a line of trees on the Low Weald has continuously increased between 1946 2015; but on the Downs these lines of trees have increased from 1946 to 1960 then gone into decline from 1960 to 2015.

Overall individual lone trees, hedgerow trees and trees forming a line have increased or only slightly decreased from 1946 to 2015 for both physiographic regions, with the Low Weald having the higher numbers.



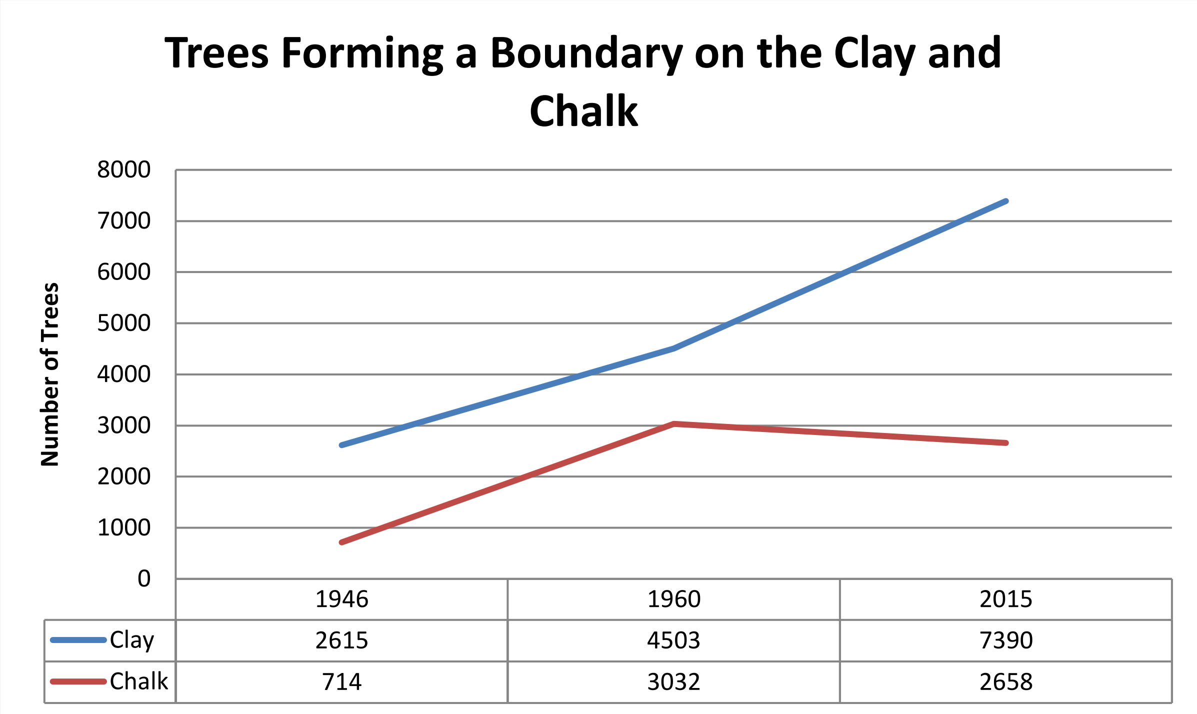
	1946	1960	2015
Clay	1077	1180	1900
Chalk	821	1167	1343

Figure 4.4: Number of individual lone trees identified on the Low Weald and Downs



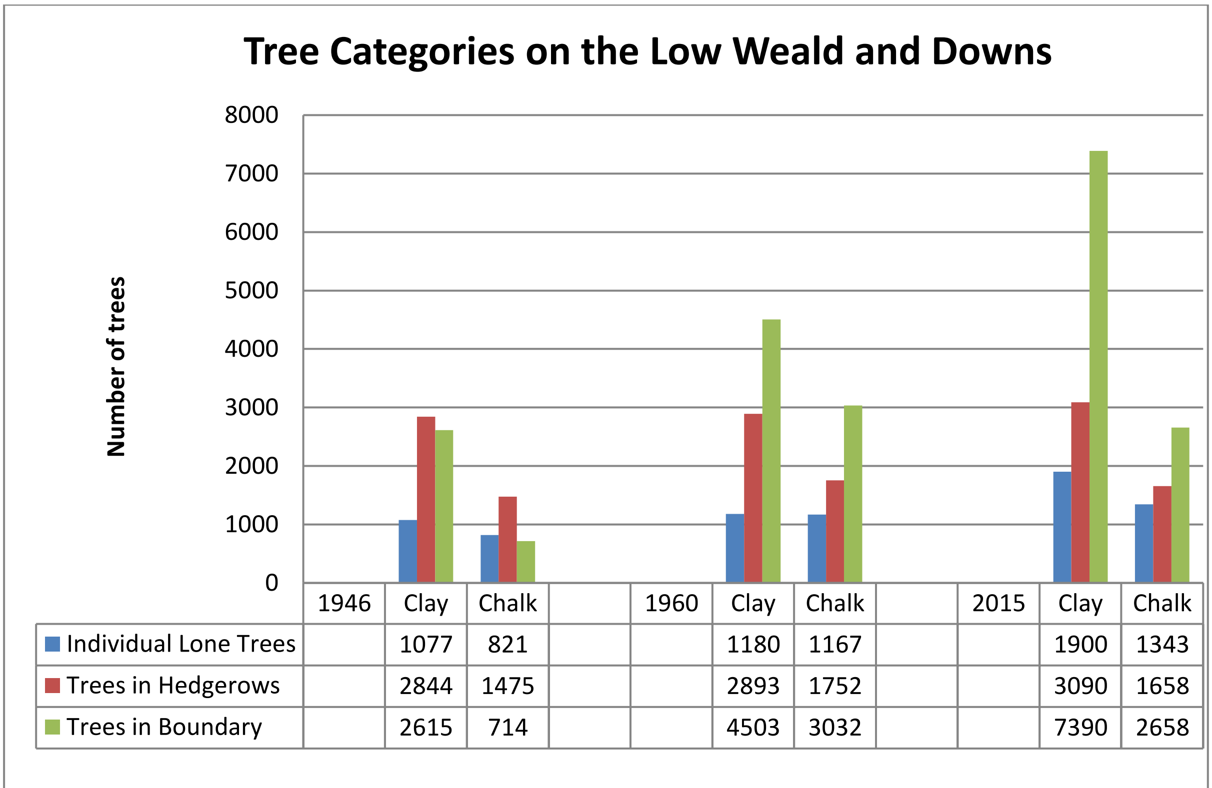
	1946	1960	2015
Clay	2844	2893	3090
Chalk	1475	1752	1658

Figure 4.5: Number of hedgerow trees identified on the Low Weald and Downs



	1946	1960	2015
Clay	2615	4503	7390
Chalk	714	3032	2658

Figure 4.6: Number of trees that formed a boundary on the Low Weald and Downs



	1946	Clay	Chalk	1960	Clay	Chalk	2015	Clay	Chalk
Individual Lone Trees		1077	821		1180	1167		1900	1343
Trees in Hedgerows		2844	1475		2893	1752		3090	1658
Trees in Boundary		2615	714		4503	3032		7390	2658

Figure 4.7: Number of trees for the three tree categories on the Low Weald and Downs

4.3: Fieldwork Results

This section displays the results generated from the data gathered from the fieldwork aspect of this research, concerning the presence or absence of microhabitats on farmland trees

4.4: Number of Microhabitats Present per Tree on the Downs

Figure 4.8 displays the quantity of microhabitats present per tree studied on the Downs region. Six species of tree were identified with an ash having the largest number of microhabitats present at seventeen and a beech with the least with three. The average number of microhabitats present for the chalk region was nine.

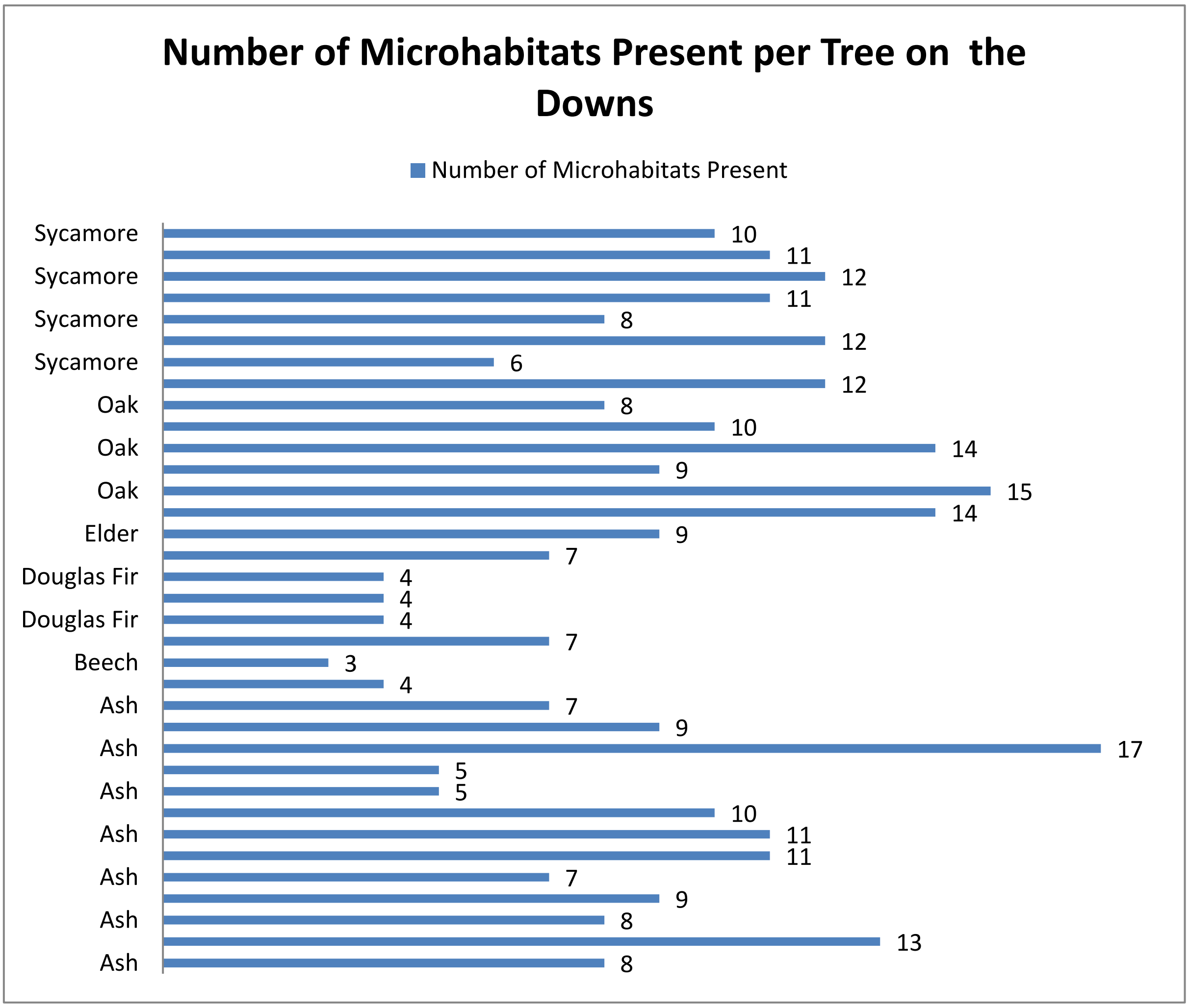


Figure 4.8: Number of microhabitats present per tree on the Downs

4.5: Number of Microhabitats Present per Tree on the Low Weald

Figure 4.9 displays the amount of microhabitats present per tree studied on the Low Weald region. Three species of tree were identified with an oak having the lowest number of microhabitats present at six as well as an oak having the highest at fifteen. The average number of microhabitats present for the Low Weald region was eleven. The trees studied on the Low Weald had a higher average of microhabitats present then the trees on the Downs. However, for both regions the ash and oak trees had similar numbers of microhabitats. This can indicate that the geology of a region does not have a direct influence on the production of microhabitats, but can have an influence on the species of tree which establish in a region which would then influence the production of microhabitats.

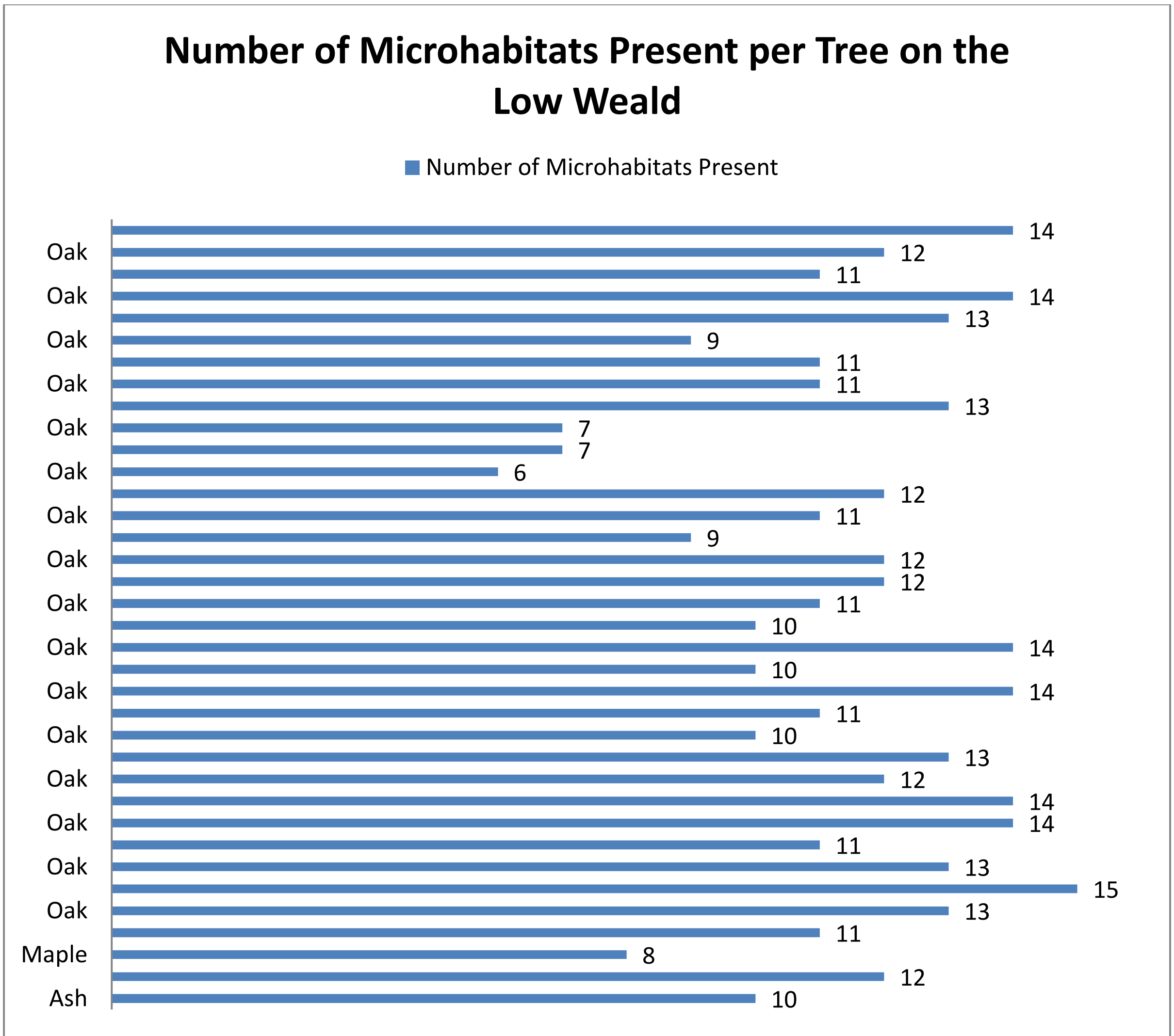


Figure 4.9: Number of microhabitats present per tree on the Low Weald

4.6: Preliminary Pilot Study Results

Figure 4.10 displays the quantity of microhabitats present on each tree studied on the Ashdown Beds region. Five species of tree were identified, with an oak having the lowest number of microhabitats present with four and both a sycamore and an oak having the highest with thirteen. The average number of microhabitats present on the trees studied on the Hastings geology was eight.

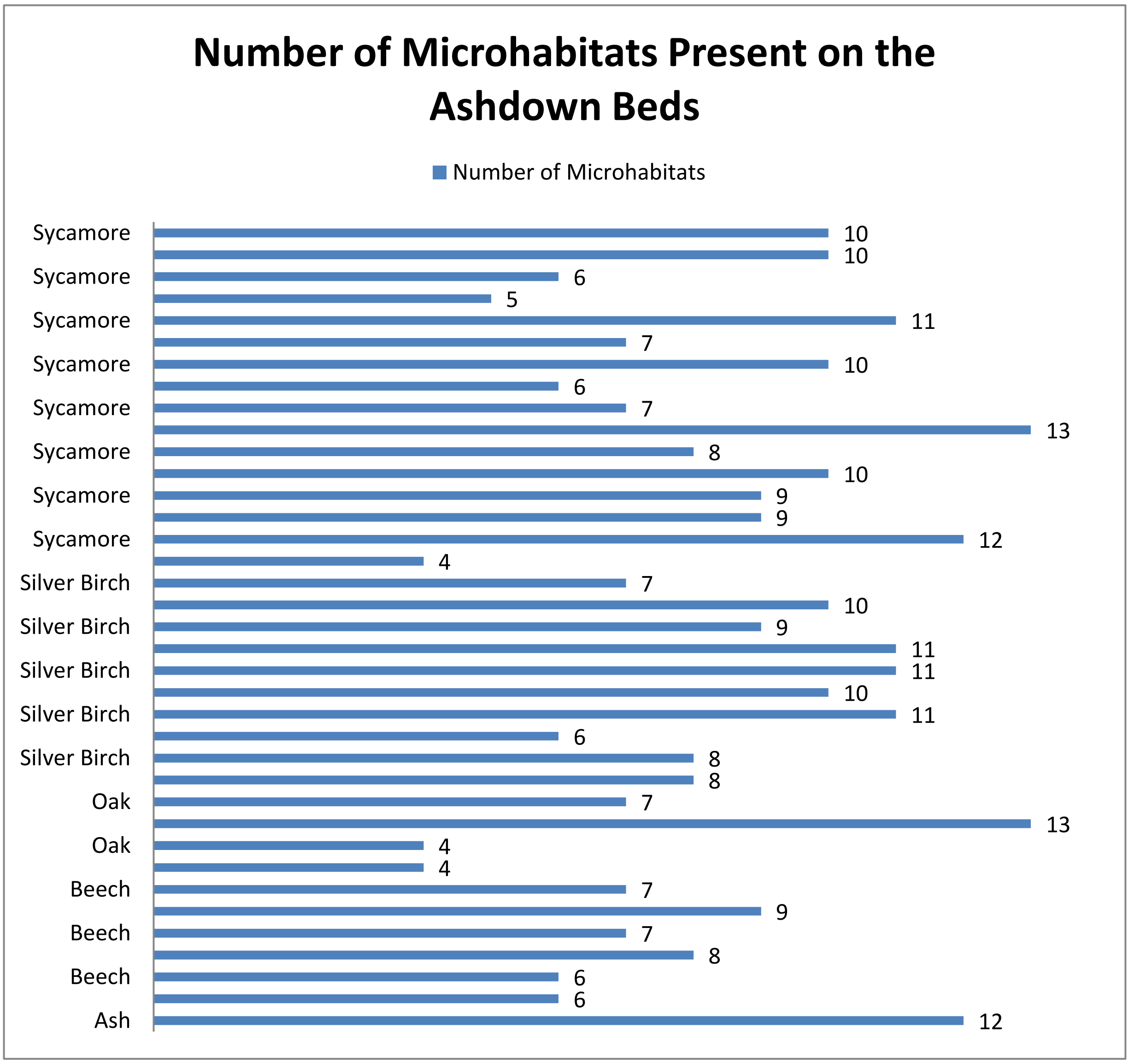


Figure 4.10: Number of microhabitats present on the Ashdown Beds

The results displayed in figure 4.10 are the results from the preliminary pilot study conducted before the other two physiographic regions.

4.7: Microhabitats Present on the Three Regions Studied

Thirty six trees were studied on the Low Weald, thirty five on the Downs and thirty seven on the Ashdown Beds. The results in table 4.3 (pp. 64-65) highlight the number of trees which had particular microhabitats present. For example, thirty six out of the thirty six tress studied on the low weald had broken or cut branches.

Eight microhabitat classifications were not present on the Ashdown Beds region compared to four not present on the Low Weald and only one on the Downs. Sap flow was the only microhabitat not present on any of the trees on any region. The largest occurrence of a microhabitat was the splintered subsidiary branch on the Hastings region. The Low Weald had five of the highest totals of microhabitats present.

Microhabitats	**Low Weald**	**Downs**	**Ashdown Beds**
Less than 50% Crown Broken	27	27	26
More than 50% Crown Broken	9	8	11
Breakout/ Tearout Wound	21	23	25
Splintered Subsidiary Branch	35	24	37
Compression Fork Split	7	11	29
Conk of Fungi	2	4	6
Rot Hole Cavity	22	21	9
Occluding Wound	17	14	26
Woodpecker Cavity	0	2	0
Cavity String	0	1	0
Deep Stem Cavity	2	2	0
Crack	28	16	22
Mould/ Water/Bark Pocket	34	26	0
Debarked Area	36	16	27
Canker	4	1	0
Witch Broom	13	14	0
Epicormic Growth	13	3	0
Sap Flow	0	0	0
Ivy	23	12	25
Broken/Cut Branches	36	32	29

Dead Wood	36	24	6
Lichens, Moss, Fungi	36	18	25
Invertebrates	11	7	9
Bird Nests/Holes	0	6	2

Table 4.3: Microhabitats Present on the three regions studied

4.8: Tree DBH and Number of Microhabitats Present

Figure 4.11 (p.66) displays the DBH, (diameter at breast height) of the accessible trees studied and the number of microhabitats present,, to analyse if the presence of microhabitats is affected by the size and potential age of a tree. These results suggest that a tree with a smaller DBH can still produce a high number of microhabitats. For the Low Weald region for example, the two largest DBH was two metres twenty eight centimetres with thirteen and fourteen microhabitats present, whilst the smallest DBH was one metre ninety centimetres with nine microhabitats. On the Downs the largest DBH was at two metres fifty centimetres with fourteen microhabitats, whilst the smallest DBH was twenty seven centimetres with eight microhabitats. Finally on the Hastings region the three joint largest DBH at one metre eighty centimetres had five, eight and thirteen microhabitats, whilst the smallest DBH was twenty centimetres with seven microhabitats.

For the three regions the smallest DBH measured was on the Hastings region at twenty centimetres with seven microhabitats and the largest DBH was on the Downs at two metres fifty centimetres with fourteen microhabitats. Trees with a smaller DBH are typically younger than those with a larger DBH. Therefore, these results indicate that smaller and younger trees are able to produce some of these specialised microhabitats typically created when trees are older.

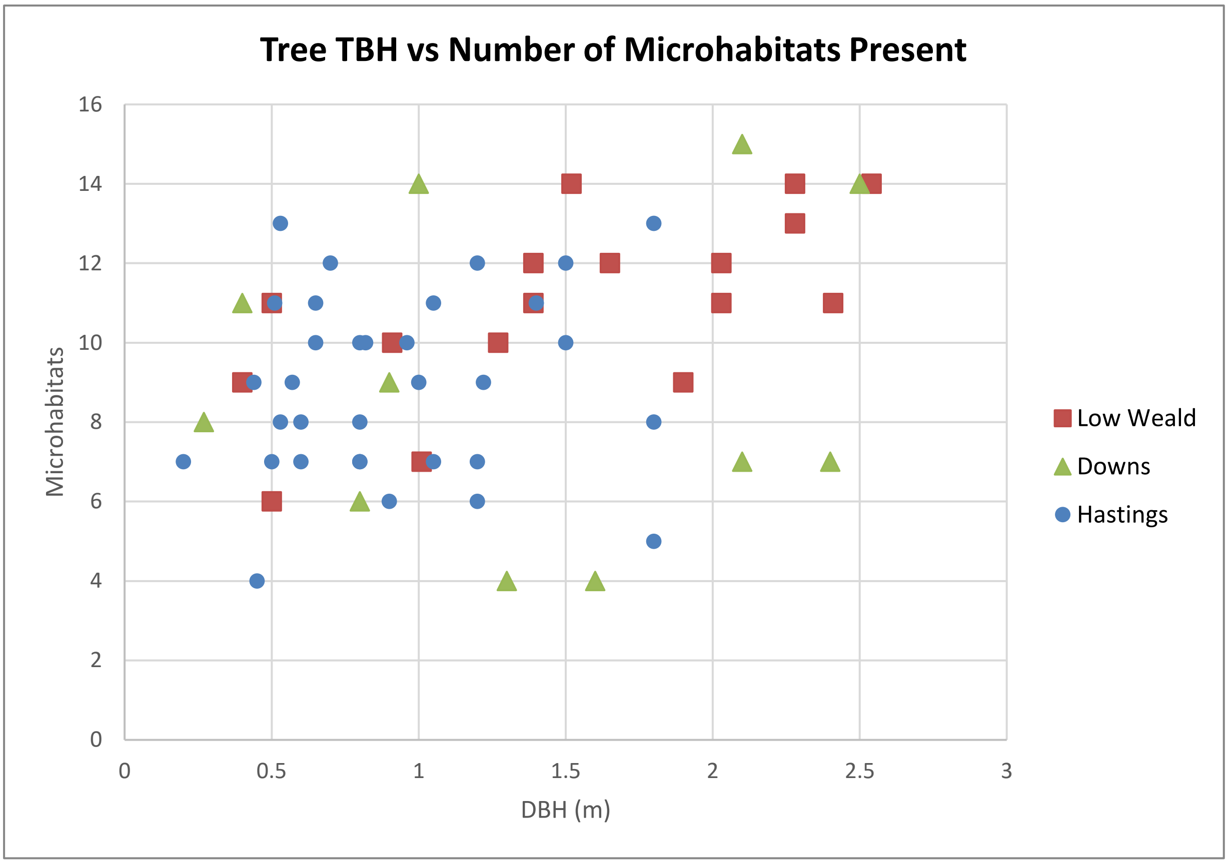


Figure 4.11: Tree DBH and number of microhabitats present

5. Discussion

This project set out to assess the impact of agricultural change and farming practices on farmland trees and hedgerows as a landscape and ecological resource, with particular focus on the Kent landscape. This is a landscape level survey of change on key landscape features, in particular hedgerows and farmland trees. This research has shown that there have been significant changes to landscape elements within Kent, which has and will continue to have a profound impact on Britain's countryside conservation and its biodiversity.

5.1: Statistical Analysis

Statistical analysis was conducted to ascertain if there were statistically significant differences between the different hedgerow categories and the physiographic region and between the physiographic regions and the number of trees. These results therefore, highlighted the different time periods that the physiographic landscapes went through agricultural landscape changes. The most dramatic result within the Low Weald and the Downs concerns the 90-100% hedged category, where the length has decreased over fifty percent from 1946 to 2015. As the other four categories do not dramatically increase or decrease from 1946 and 1960 it can highlight that the changes in the landscape had a bigger effect from 1960 onwards. This result can be explained by the decrease of the 90-100% hedged boundaries, as over the years they have become 'gappy' hedgerows. The 1-50% hedged, other boundary and tree boundary all increase between 1946 and 1960sand then decline between 1960 and 2015. This result also coincides with the decline of the 90-100% hedged category, with hedgerows becoming 'gappy' or developing into lines of trees.

A two sample t-test highlighted that even though the Low Weald had more trees, there was not a statistically significant difference between the number of individual trees on the Downs and the Low Weald in 1946 and 1960. There was however, a statistically significant difference between the number of individual trees between the Low Weald and the Downs in the present day.

For the Low Weald, the increase of individual trees between 1946 and 1960 was not statistically significant, whereas the increase between 1960 and 2015 was statistically significant. This indicates that the period of dramatic agricultural change for this physiographic region occurred from 1960.

For the Downs, the results are the opposite to the clay as the increase of individual trees on farmland between 1946 and 1960 was statistically significant, whereas between 1960 and 2015the increase was not statistically significant. This indicates that for this physiographic region the greatest changes occurred between 1946 and 1960.

Data that was not statistically analysed was the data involving the number of trees that formed a line. The reliability concerning the counting of these trees from the aerial photos could be questioned which was why it was decided not to use this data for any statistical testing. The data involving the changes in hedgerow trees on the Low Weald and Downs were not considered dramatic increases or decreases to warrant statistical testing to be conducted on.

A summary concerning the results from the statistical testing can be found below:

- There is no statistically significant difference between the lengths of 90-100% hedged boundaries in 1946 and 1960 on the Low Weald landscape. On the other hand, there is a statistically significant difference between the lengths of 90-100% hedged boundaries in 1946 and 1960 on the Downs landscape.

- There is a statistically significant difference between the lengths of 90-100% hedged boundaries in 1960 and 2015 on the Low Weald. There is also a statistically significant difference between the lengths of 90-100% hedged boundaries between 1960 and 2015 on the Downs landscape.

- There is no statistically significant difference between the number of individual lone trees in 1946 and 1960 on the Low Weald landscape. But, there is a statistically significant difference between the number of individual trees in 1946 and 1960 on the Downs landscape.

- There is a statistically significant difference between the number of individual lone trees in 1960 and 2015 on the Low Weald landscape. However, there is no statistically significant difference between the number of individual lone trees in 1960 and 2015 on the Downs landscape.

- There is no statistically significant difference between the number of individual lone trees on the Downs and Low Weald landscape in 1946. There is also no statistically significant difference between the number of individual lone trees on the Downs and Low Weald landscape in 1960. But, there is a statistically significant difference between the number of individual trees in 2015 on the Low Weald and Downs landscape.

5.2: Statistical Results

Statistics for the Length of 90-100% Hedged Boundaries on the Low Weald Landscape in 1946s and 1960

Null hypothesis: There is no statistically significant difference between the lengths of 90-100% hedged boundaries in 1946 and 1960 on the Low Weald landscape.

Descriptive Statistics: Clay 1940 90-100% Hedged, Clay 1960 90-100% Hedged

Variable	N	Mean	SE Mean	StDev	Variance	Minimum	Q1	Median	Q3	Maximum
Clay 1946, 90-100% Hedged	30	12.255	0.861	4.713	22.216	0.517	8.677	11.756	16.219	20.191
Clay 1960 90-100% Hedged	30	10.790	0.772	4.226	17.858	0.428	8.409	11.097	13.915	17.949

Variance values: 22.216/17.858 = 1.24 Critical value on f distribution is 1.62. Critical value was higher than variance value so equal variance for t-test was assumed.

Two-Sample T-Test and CI: Clay 1940 90-100% Hedged, Clay 1960 90-100% Hedged

	N	Mean	StDev	SE Mean
Clay 1946, 90-100% Hedged	30	12.26	4.71	0.86
Clay 1960, 90-100% Hedged	30	10.79	4.23	0.77

T-Test of difference = 0 (vs ≠): T-Value = 1.27 P-Value = 0.210

Critical t value to the appropriate degrees of freedom = 2.00. T-value is less than the critical t value so the null hypothesis is accepted because there is no statistically significant difference between the lengths of 90-100% hedged boundaries in 1946 and 1960 on the clay landscape.

Statistics for the Length of 90-100% Hedged Boundaries on the Low Weald Landscape in 1960 and 2015

Null hypothesis: There is no statistically significant difference between the lengths of 90-100% hedged boundaries in 1960 and 2015 on the Low Weald landscape.

Descriptive Statistics: Clay 1960 90-100% Hedged, Clay Present 90-100% Hedged

Variable	N	Mean	SE Mean	StDev	Variance	Minimum	Q1	Median	Q3	Maximum
Clay 1960, 90-100% Hedged	30	10.790	0.772	4.226	17.858	0.428	8.409	11.097	13.915	17.949
Clay 2015, 90-100% Hedged	30	5.693	0.398	2.180	4.751	2.076	4.173	5.590	7.401	9.729

Variance values: – 17.858/4.751= 3.76. Critical value on f distribution is 1.62. Critical value was less then variance value, so equal variance for t-test was not assumed.

Two-Sample T-Test and CI: Clay 1960 90-100% Hedged, Clay Present 90-100% Hedged

	N	Mean	StDev	SE Mean
Clay 1960, 90-100% Hedged	30	10.79	4.23	0.77
Clay 2015,	30	5.69	2.18	0.40

90-100% Hedged

T-Test of difference = 0 (vs ≠): T-Value = 5.87 P-Value = 0.000

Critical t value to the appropriate degrees of freedom = 2.00. T-value is higher than the critical t value so the null hypothesis is rejected because there is a statistically significant difference between the lengths of 90-100% hedged boundaries in the 1960s and present day on the clay geology.

Statistics for the Length of 90-100% Hedged Boundaries on the Downs Landscape in the 1940s and the 1960s

Null hypothesis: There is no statistically significant difference between the lengths of 90-100% hedged boundaries in the 1940s and the 1960s on the Downs landscape.

Descriptive Statistics: Chalk 1940 90-100% Hedged, Chalk 1960 90-100% Hedged

Variable	N	Mean	SE Mean	StDev	Variance	Minimum	Q1	Median	Q3	Maximum
Chalk 1940, 90-100% Hedged	30	8.690	0.699	3.827	14.649	1.466	5.944	7.140	12.089	16.207
Chalk 1960, 90-100% Hedged	30	5.891	0.458	2.509	6.297	1.825	4.171	5.115	7.745	12.862

Variance values: – 14.649/6.297=2.32634588. Critical value on f distribution is 1.62. Critical value was less than the variance value so equal variance was not assumed for the t-test.

Two-Sample T-Test and CI: Chalk 1940 90-100% Hedged, Chalk 1960 90-100% Hedged

	N	Mean	StDev	SE Mean
Chalk 1940, 90-100% Hedged	30	8.69	3.83	0.70
Chalk 1960, 90-100% Hedged	30	5.89	2.51	0.46

T-Test of difference = 0 (vs ≠): T-Value = 3.35 P-Value = 0.002

Critical t value to the appropriate degrees of freedom =2.00. T-value is higher than the critical t value so the null hypothesis is rejected because there is a statistically significant difference between the lengths of 90-100% hedged boundaries in the 1940s and the 1960s on the chalk landscape.

Statistics for the Length of 90-100% Hedged Boundaries on the Downs Landscape in the 1960s and the Present Day

Null hypothesis: There is no statistically significant difference between the lengths of 90-100% hedged boundaries in the 1960s and the present day on the Downs landscape.

Descriptive Statistics: Chalk 1960 90-100% Hedged, Chalk Present 90-100% Hedged

Variable	N	Mean	SE Mean	StDev	Variance	Minimum	Q1	Median	Q3	Maximum
Chalk 1960, 90-100%	30	5.891	0.458	2.509	6.297	1.825	4.171	5.115	7.745	12.862
Chalk Present, 90-100% Hedged	30	3.867	0.301	1.649	2.719	1.497	2.440	3.765	5.163	7.656

Variance values: – 6.297/2.719=2.32.Critical value on f distribution is 1.62. Critical value was less than the variance value so equal variance was not assumed for the t-test.

Two-Sample T-Test and CI: Chalk 1960 90-100% Hedged, Chalk Present 90-100% Hedged

	N	Mean	StDev	SE Mean
Chalk 1960, 90-100% Hedged	30	5.89	2.51	0.46
Chalk Present, 90-100% Hedged	30	3.87	1.65	0.30

T-Test of difference = 0 (vs ≠): T-Value = 3.69 P-Value = 0.001

Critical t value to the appropriate degrees of freedom = 2.00. T-value is higher than the critical t value so the null hypothesis is rejected because there is a statistically significant difference between the lengths of 90-100% hedged boundaries between the 1960s and present day on the chalk landscape.

Statistics for the Number of Individual Trees on the Low Weald Landscape in 1946 and 1960

Null hypothesis: There is no statistically significant difference between the number of individual lone trees in 1946 and 1960 on the Low Weald landscape

Descriptive Statistics: Clay 1940 Individual Trees, Clay 1960 Individual Trees

Variable	N	Mean	SE Mean	StDev	Variance	Minimum	Q1	Median	Q3	Maximum
Clay 1946, Individual Trees	30	35.90	5.01	27.47	754.37	4.00	14.50	31.50	48.25	114.00
Clay 1960, Individual Trees	30	39.33	4.65	25.47	648.78	1.00	21.75	38.50	52.25	117.00

Variance value: – 754.37/648.78= 1.16. Critical value on f distribution is 1.62. Critical value was less than the variance value, so equal variance was not assumed for the t-test.

Two-Sample T-Test and CI: Clay 1940 Individual Trees, Clay 1960 Individual Trees

	N	Mean	StDev	SE Mean
Clay 1946, Individual Trees	30	35.9	27.5	5.0
Clay 1960, Individual Trees	30	39.3	25.5	4.7

T-Test of difference = 0 (vs ≠): T-Value = -0.50 P-Value = 0.618

Critical t value to the appropriate degrees of freedom = 2.00. T-value is lower than the critical t value so the null hypothesis is accepted because there is no statistically significant difference between the number of individual lone trees in the 1940s and 1960s on the clay landscape.

Statistics for the Number of Individual Trees on the Low Weald Landscape in 1960 and the 2015

Null hypothesis: There is no statistically significant difference between the number of individual lone trees in 1960 and 2015 on the Low Weald landscape

Descriptive Statistics: Clay 1960 Individual Trees, Clay Present Individual Trees

Variable	N	Mean	SE Mean	StDev	Variance	Minimum	Q1	Median	Q3	Maximum
Clay 1960, Individual Trees	30	39.33	4.65	25.47	648.78	1.00	21.75	38.50	52.25	117.00
Clay 2015, Individual Trees	30	63.33	5.35	29.30	858.78	7.00	42.25	59.00	85.25	137.00

Variance Value: – 858.78/648.78= 1.32. Critical value on f distribution is 1.62. Critical value was less than the variance value, so equal variance was not assumed for the t-test.

Two-Sample T-Test and CI: Clay 1960 Individual Trees, Clay Present Individual Trees

	N	Mean	StDev	SE Mean
Clay 1960, Individual Trees	30	39.3	25.5	4.7
Clay 2015, Individual Trees	30	63.3	29.3	5.4

T-Test of difference = 0 (vs ≠): T-Value = -3.39 P-Value = 0.001 DF = 56

Critical t value to the appropriate degrees of freedom = 2.00. T-value is higher than the critical t value so the null hypothesis is rejected because there is a statistically significant difference between the number of individual lone trees in 1960 and 2015 on the clay landscape.

Statistics for the Number of Individual Trees on the Downs Landscape in 1946 and 1960

Null hypothesis: There is no statistically significant difference between the number of individual lone trees in 1946 and 1960 on the Downs landscape

Descriptive Statistics: Chalk 1940 Individual Trees, Chalk 1960 Individual Trees

Variable	N	Mean	SE Mean	StDev	Variance	Minimum	Q1	Median	Q3	Maximum
Chalk 1946, Individual Trees	30	27.37	3.79	20.78	431.62	5.00	11.00	22.00	37.75	97.00
Chalk 1960, Individual Trees	30	38.90	4.22	23.10	533.54	4.00	20.75	32.50	59.00	87.00

Variance Value: – 533.54/431.62= 1.23613364. Critical value on f distribution is 1.62. Critical value was higher than the variance value, so equal variance was assumed for the t-test.

Two-Sample T-Test and CI: Chalk 1940 Individual Trees, Chalk 1960 Individual Trees

	N	Mean	StDev	SE Mean
Chalk 1946, Individual Trees	30	27.4	20.8	3.8
Chalk 1960, Individual Trees	30	38.9	23.1	4.2

T-Test of difference = 0 (vs ≠): T-Value = -2.03 P-Value = 0.047

Critical t value to the appropriate degrees of freedom = 2.00. T-value is higher than the critical t value so the null hypothesis is rejected because there is a statistically significant difference between the number of individual trees in 1946 and 1960 on the chalk landscape.

Statistics for the Number of Individual Trees on the Downs Landscape in 1960 and the 2015

Null hypothesis: There is no statistically significant difference between the number of individual lone trees in 1960 and 2015 on the Downs landscape

Descriptive Statistics: Chalk 1960 Individual Trees, Chalk Present Individual Trees

Variable	N	Mean	SE Mean	StDev	Variance	Minimum	Q1	Median	Q3	Maximum
Chalk 1960, Individual Trees	30	38.90	4.22	23.10	533.54	4.00	20.75	32.50	59.00	87.00
Chalk 2015, Individual Trees	30	44.77	4.92	26.93	725.01	1.00	28.50	36.50	57.00	110.00

Variance value: – 725.01/533.54= 1.36. Critical value on f distribution is 1.62. Critical value was higher than the variance value, so equal variance was assumed for the t-test.

Two-Sample T-Test and CI: Chalk 1960 Individual Trees, Chalk Present Individual Trees

	N	Mean	StDev	SE Mean
Chalk 1960, Individual Trees	30	38.9	23.1	4.2
Chalk 2015, Individual Trees	30	44.8	26.9	4.9

T-Test of difference = 0 (vs ≠): T-Value = -0.91 P-Value = 0.369

Critical t value to the appropriate degrees of freedom = 2.00. T-value is less than the critical t value so the null hypothesis is accepted because there is no statistically significant difference between the number of individual lone trees in 1960 and 2015 on the chalk landscape.

Statistics for the Number of Individual Trees between the Low Weald and Downs Landscapes in 1946s

Null hypothesis: There is no statistically significant difference between the number of individual lone trees in 1946 on the Low Weald and Downs landscape

Descriptive Statistics: Clay 1940 Individual Trees, Chalk 1940 Individual Trees

Variable	N	Mean	SE Mean	StDev	Variance	Minimum	Q1	Median	Q3	Maximum
Clay 1946, Individual Trees	30	35.90	5.01	27.47	754.37	4.00	14.50	31.50	48.25	114.00
Chalk 1946, Individual Trees	30	27.37	3.79	20.78	431.62	5.00	11.00	22.00	37.75	97.00

Variance value: - 754.37/431.62= 1.75. Critical value on f distribution is 1.62. Critical value was lower than the variance value so equal variance was not assumed for the t-test.

Two-Sample T-Test and CI: Clay 1940 Individual Trees, Chalk 1940 Individual Trees

	N	Mean	StDev	SE Mean
Clay 1946, Individual Trees	30	35.9	27.5	5.0
Chalk 1946, Individual Trees	30	27.4	20.8	3.8

T-Test of difference = 0 (vs ≠): T-Value = 1.36 P-Value = 0.180

Critical t value to the appropriate degrees of freedom = 2.00. T-value is less than the critical t value so the null hypothesis is accepted because there is no statistically significant difference between the number of individual lone trees on the chalk and clay landscape in 1946.

Statistics for the Number of Individual Trees between the Low Weald and Downs Landscapes in 1960

Null hypothesis: There is no statistically significant difference between the number of individual lone trees in 1960 on the Low Weald and Downs landscape

Descriptive Statistics: Clay 1960 Individual Trees, Chalk 1960 Individual Trees

Variable	N	Mean	SE Mean	StDev	Variance	Minimum	Q1	Median	Q3	Maximum
Clay 1960, Individual Trees	30	39.33	4.65	25.47	648.78	1.00	21.75	38.50	52.25	117.00
Chalk 1960, Individual Trees	30	38.90	4.22	23.10	533.54	4.00	20.75	32.50	59.00	87.00

Variance value: - 648.78/533.54= 1.22. Critical value on f distribution is 1.62. Critical value was higher than the variance value, so equal variance was assumed for the t-test.

Two-Sample T-Test and CI: Clay 1960 Individual Trees, Chalk 1960 Individual Trees

	N	Mean	StDev	SE Mean
Clay 1960, Individual Trees	30	39.3	25.5	4.7
Chalk 1960, Individual Trees	30	38.9	23.1	4.2

T-Test of difference = 0 (vs ≠): T-Value = 0.07 P-Value = 0.945

Critical t value to the appropriate degrees of freedom = 2.00. T-value is less than the critical t value so the null hypothesis is accepted because there is no statistically significant difference between the number of individual lone trees on the chalk and clay landscape in 1960.

Statistics for the Number of Individual Trees between the Low Weald and Downs Landscapes in 2015

Null hypothesis: There is no statistically significant difference between the number of individual lone trees in 2015 on the Low Weald and Downs landscape

Descriptive Statistics: Clay Present Individual Trees, Chalk Present Individual Trees

Variable	N	Mean	SE Mean	StDev	Variance	Minimum	Q1	Median	Q3	Maximum
Clay 2015, Individual Trees	30	63.33	5.35	29.30	858.78	7.00	42.25	59.00	85.25	137.00
Chalk 2015, Individual Trees	30	44.77	4.92	26.93	725.01	1.00	28.50	36.50	57.00	110.00

Variance value: - 858.78/725.01= 1.185. Critical value on f distribution is 1.62. Critical value was higher than the variance value, so equal variance was assumed for the t-test.

Two-Sample T-Test and CI: Clay Present Individual Trees, Chalk Present Individual Trees

	N	Mean	StDev	SE Mean
Clay 2015, Individual Trees	30	63.3	29.3	5.4
Chalk 2015, Individual Trees	30	44.8	26.9	4.9

T-Test of difference = 0 (vs ≠): T-Value = 2.56 P-Value = 0.013

Critical t value to the appropriate degrees of freedom = 2.00. T-value is higher than the critical t value so the null hypothesis is rejected because there is a statistically significant difference between the number of individual trees in 2015 on the clay and chalk landscape.

5.3: Farmland Boundaries

The decline in the continuous hedgerow length (90-100% category), from 1946 to 2015 for both physiographic regions can be explained by several factors. Firstly, many hedgerows have become discontinuous ('gappy') as a result of poor management and removal, this will account for the overall rise in length for the two other categories (50-90% and 1-50%). For example, where land has been converted to arable production, stock-proof hedgerows become less important as they were primarily used as a barrier to stop animals accessing other fields; leading to hedgerow neglect or uprooting. Where 'gappy' hedgerows are part of pastoral land, they may simply be patched with wire fences. Secondly, some hedgerows may have been removed and replaced by wire fences or, if no barrier is required, may simply be left as a grass strip. Finally, some of the loss will be the result of field amalgamation to facilitate mechanisation, for examples (see appendix 3, chalk squares 24, 86, 62 and 110 and clay squares 570, 528, 535 and 493).

The overall increase in the 50-90% and 1-50% categories in both physiographic regions can be explained by the decline in the 90-100% category. Many farmers neglected their hedgerows through the years. The lack of management resulted in the creation of ‘gappy’ hedgerows or lines of trees. Research by MacDonald and Johnson, (1995) examined the relationship between the structural and botanical characteristics of hedgerows and bird populations associated with them. They highlighted that both neglect and excessive management were likely to have a negative effect on the abundance of many local species. MacDonald and Johnson, (1995) concluded that some form of hedgerow management is needed. This conclusion is also supported by Sparks and Martin, (1999) who highlight the understanding that to prevent hedgerow degeneration management is needed. Neglected hedgerows develop gaps which affects the hedgerows function as barrier, resulting in a poor quality habitat for wildlife. Over managed hedgerows by trimming or flailing can also have a negative effect on wildlife populations because over management can lead to the removal of food sources, nesting and breeding sites (Sparks and Martin, 1999).Therefore, farmers are encouraged to not trim their hedgerows too frequently and to wait until the winter months when birds have fledged (Bannister and Watt, 1995). For Kent, the overall increase in the 50-90% and 1-50% categories indicates the amount of neglect and lack of management that hedgerows on farmland faced from 1946.

Hawthorn is traditionally the most favoured and successful hedging to plant in England because hawthorn hedgerows are fast growing, are very dense and thorny making them a good stock proof hedge, can be exposed to root disturbance and agrochemicals, can be pruned annually and have the ability to recover from disturbances and damage (Bannister and Watt, 1995). However, hawthorn hedgerows were prominent features in conventional arable farming systems so there are questions as to how they recover from modern farming practices. MacDonald and Johnson, (1995) and Bannister and Watt, (1995) identify that hedgerow quality declines because of the lack of maintenance and that Hawthorn is unsuited in some unspecified conditions to mechanical cutting. Studies on Britain's field boundaries showed that over twenty percent of classified hedgerow boundaries in 1984 were a different classification in the 1990s, for example, relict hedgerows and lines of trees. This suggests that hedgerow management was less productive during the 1980s (Bannister and Watt, 1995). These general trends observed across the UK appear to have been true for Kent too, although there are differences between the Downs and the Low Weald. During the post-war period, and especially during the 1960s and 1970s, hedgerows were often removed as they became less important to the agricultural economy, this is seen on the Downs, where arable production increased and field amalgamation is clearly evident. The amalgamation of fields was an important factor contributing to the removal of hedgerows, as previously smaller enclosed fields became merged with several others, forming one large field. Hedgerows were seen as a barrier, preventing the tractor from gaining access to the whole field, removal was done to increase the means of production as well as enable the larger tractors to access, fertilise and harvest a field. Generally the fields on the Downs landscape were larger than those on the Low Weald with field expansion on the two physiographic regions studied being predominantly higher on the Downs, compared with the Low Weald, for examples (see appendix 3, chalk squares 62, 110,134, 233, 283 and 367 and clay squares 528, 535 and 577).

Field amalgamation can also explain why hedged boundaries went into decline whilst other categories of boundaries increased, for example, wired or wooden fencing was used as a replacement for hedgerows as they were cheaper to source, manage and implement. Pryor, (2011) identifies that over four hundred thousand kilometres of hedgerows have been removed since the 1950s, with the damage only being acknowledged around the 1980s. The

1950s to the 1980s was a period of agricultural intensification in Britain, so removal of hedgerows is predicted to be highest within this period. From the results of this project it can be noted that fields on the Low Weald were largely enclosed by hedgerows or tree boundaries, whilst fields on the Downs were mainly enclosed by very 'gappy' hedgerows and wired, fenced or grass verge boundaries, for examples (see appendix 3, chalk squares 24,86, 122,197, 221 and 283 and clay squares 493, 549 and 556) . One of the reasons for this could be the nature of the geology because the Downs has been developed for arable farming, while the Low Weald region has generally remained more mixed with pasture which can explain the reason for less hedge removal on the Low Weald.

Different species of hedge and tree grow better in different soils (Fitter, 2002). This can generate different organisms growing in different physiographic regions. Clay soils are generally fertile but are easily waterlogged and crack when dry, leading to poor drainage (Royal Horticultural Society, 2015). Having fertile soils means more organisms like hedgerows are able to grow in this region. The opposite can be said for the chalk soil which is very dry as it does not retain much water and is less fertile then the clay (Royal Horticultural Society, 2015). The lack of fertile soil in this physiographic region means more species have to compete with each other to absorb the nutrients and minerals from the soil to establish and grow. The differing soil conditions and fertility levels will therefore have an impact on the species structure of a landscape (Starr, 2013) because different species will require various environmental conditions to grow and develop. Hedgerows and trees surrounding fields of crops on the chalk can prevent the crops from obtaining the water needed to sustain growth as it causes a competition to obtain the water source. If farmers believed that hedgerows and trees would have an effect on their crops growth then they would remove the hedgerows to give their crops a better chance to grow. Replacing hedgerows with fencing, either wired or wooden can be a cheaper way for farmers to manage their boundaries because they require less management than hedgerows, for examples (see appendix 3, chalk squares 24, 86, 122,197, 221 and 283 and clay squares 500, 507, 521 and 535). This highlights the fact that farmers still choose their management practices based on an economic value rather than environmental considerations. However, evidence from aerial imagery and fieldwork showed that some fields had fencing placed in front of a hedgerow or tree boundary. This was also supported by evidence through fieldwork where some of the fields with a hedgerow or lines of trees had a fenced boundary placed approximately a metre in front. A reason for farmers doing this could be to give the hedgerows and trees room to grow and to avoid being damaged and cut when crops are harvested.

The results from this project are broadly consistent with the academic literature concerning hedgerow lengths in Britain. The decline in hedgerow length and its quality can be linked directly to the academic literature regarding intensification and mechanisation. Devaeminck, *et al.,* (2005) argued that the intensification of agriculture is one of the main factors that has led to the degradation and loss of field boundaries including hedgerows and hedgerow trees. Both Rackham, (1986) and Croxton, *et al.,* (2004) highlight that the uprooting of approximately half of Britain's hedgerows were to facilitate the changing practices on farms because of the increased need in food production. This resulted in larger fields being created to accommodate the larger machinery and crop sprayers being used. The decline in hedgerow length and quality highlighted within this project correspond with the above literature regarding the intensification of the agricultural system during and after the war period. It can be concluded that intensification and mechanisation will still be a contributing factor in the loss of hedgerows to date and are arguably the main factors contributing to the reasoning behind these results.

5.4: Farmland Trees

Farmland on the Low Weald had more lone trees then those on the Downs; this could be influenced by a number of factors including the drainage of the landscape, the decline in hedgerows and individual farmer’s perceptions on the importance of the trees on their land. Farmers may remove trees which are more mature, that compete for water with their crop or interfere with their mechanical trimming devices, but this can be considered to be an indirect effect (MacDonald and Johnson, 1995). The number of trees has increased over the years on the Downs; this could be to do with incentives to encourage the continuous growth of farmland trees and can also be linked to the decline in 90-100% hedgerows. One factor that has led to an increase in the observed number of isolated trees within fields is the removal of hedgerows. As hedgerows were removed to facilitate mechanisation, any large trees were either removed from the landscape or left standing within a field; with farming practices continuing to occur around them, for examples (see appendix 3, chalk squares 122, 221, 242, 307 and 343 and clay square 493, 514 and 584).

The decrease of hedgerow trees on the Downs from 1960 to 2015 can be linked to the increase of individual trees on the Downs during that time. This change can be explained by a change in classification rather than the loss of trees. 90-100% hedgerows have continuously declined between 1946 and 2015. Therefore, hedgerows would have been removed but some trees may have been left causing a tree to previously be categorized as a hedgerow tree to be newly classified as an individual tree, for example, (see appendix 3, chalk squares 122 and 242 and clay squares 493, 514 and 584).

The increase on the Low Weald for the trees that form a line could be explained by lack of management on farmland where hedgerows have grown into trees. Lines of trees usually occur if a hedgerow has been left unmanaged, allowing the trees to grow or are planted specifically by the landowners to act as a field barrier. The decrease on the Downs could be down to over management where lines of trees could have turned back into hedgerows, for example (see appendix 3, chalk squares 48, 171 and 185 and clay square 577). On the Downs between the 1960s and present, lines of trees forming a boundary could have gone into decline if they were once part of a hedgerow that was removed which would also explain the increase of individual trees. Unless the hedgerows and trees are part of the ancient landscape it can be argued that the lines of trees have grown between 1946 and 1960. Management practices could also differ between the two physiographic regions with trees being removed from a landscape rather then left to grow and develop.

5.5. Microhabitats

Few studies have researched the management determinants of the occurrence and richness of microhabitats (Vuidot, *et al.,* 2011). A target of at least thirty trees was deemed an acceptable number to analyse for this part of the study, with thirty five trees being studied on the Downs, thirty six on the Low Weald and an additional thirty seven on the Ashdown Beds from the preliminary study (see appendix 1 for full data sets). It is widely acknowledged that hedgerows and trees on farmland are beneficial for birds and wildlife, but the large scale removal of these features from Britain's agricultural landscape is a concern regarding its effect on vulnerable farmland species that use these features as a habitat (MacDonald and Johnson, 1995).

The results from this research regarding the species of tree observed also links with the theories from Starr, (2013) and Fitter, (2002) that different species of tree can grow better than others on different soils. Starr's, (2013) conclusion can be linked to the results in this research, which showed that fifteen out of the thirty five trees studied on the Downs had ten or more microhabitats; but on the Low Weald thirty out of the thirty six trees studied had over ten microhabitats present. Six species of tree were identified on the Downs with only four identified on the Low Weald. Two of the six tree species identified on the Downs, the Douglas fir and sycamore, were not identified on the Low Weald. The average number of microhabitats per tree for the chalk region studied was eight with an ash having the largest number of microhabitats recorded at seventeen and a beech with the least with three. On the other hand the average number of microhabitats for the Low Weald was eleven with an oak having the lowest number of microhabitats recorded at six and also the highest at fifteen. This indicates that the trees studied on the Low Weald produced more microhabitats than those studied on the Downs. However, both the ash and oaks had similar averages of microhabitats present on both physiographic regions; ash produced nine on the Downs compared with ten on the Low Weald and oak produced eleven on the Downs and eleven on the Low Weald. This indicates that the same species of tree can produce similar numbers of microhabitats on different soil conditions, highlighting that the soil is not the main influence on the production of microhabitats found on farmland trees; it is the species of tree that is the main influence. Therefore, the geology of a region has a role involving the species of tree that grows successfully in the region not necessarily the production of microhabitats present on those trees.

Twenty five categories of microhabitats were recorded as either being present or absent on the trees observed. Of these twenty five, twenty microhabitats were present on the trees on the Low Weald region. The categories; broken and cut branches, dead wood, and lichens, moss and fungi were the three categories to be present on all thirty six trees observed; with splintered subsidiary branches and debarked areas present on thirty five of the thirty six. Only eleven of the twenty five microhabitat categories were present on half the number of trees observed. Four microhabitat categories; woodpecker cavity, cavity string, sap flow and bird's nests/holes, were not present on any of the thirty six trees studied on the Low Weald region. On the other hand twenty three microhabitats were present on the Downs region with only eight categories present on half of the trees studied. Compared with the Low Weald region, the highest occurrence of a microhabitat present on the trees was the broken/ cut branches with thirty two out of the thirty five trees having it present. However, only one microhabitat category was not present on any of the trees studied which was the sap flow category.

In forest studies, Vuidot, *et al.,* (2011) concluded that generally microhabitats are more abundant in un-managed forests than managed as forest management can cause a reduction in the number of trees able to host microhabitats; but microhabitats do occur in landscapes that are both managed and un-managed (Winter and Moller, 2008). All thirty six trees observed on the Low Weald had broken and cut branches compared with thirty two out of thirty five on the Downs; which can both be created as a result of farmland management involving the use of flails to trim their hedgerows, catching the trees as they pass. This method of hedgerow management also leads to branches being broken by the flail in a similar manner to a wind-snap branch categorised as a splintered subsidiary branch. The presence of broken and cut branches can be precursors for both dead wood and rot hollow forming the resultant microhabitat.

Dead wood is an important microhabitat within a landscape and the removal of dead wood over the centuries has resulted in there not being enough of these habitats to sustain key species of conservation importance. The lack of dead wood habitats has been the result of centuries of removal especially in woodland systems where dead wood was perceived to be the presence of pests including insects and was removed to protect the timber resources (Cowan, 2003). For aesthetic and safety reasons dead wood was and still is removed from any areas where the public has access. Dead wood for this research was perceived to be dead branches attached to the main tree and dead branches on the immediate ground floor. Saproxylic and bryophyte species are reliant on dead wood habitats during their life span and are becoming isolated within a landscape as the number of dead wood habitats declines, decreasing species mobility within a region (Cowan, 2003). A bridge habitat within a landscape is needed to be created to link the dead wood habitats to enable species to move within a landscape. The process of veteranisation on trees can be used alongside pruning methods, to accelerate the ageing process of trees by deliberately causing damage to a tree to induce particular microhabitats to form.

All thirty six trees on the Low Weald had the presence of dead wood, compared to twenty four out of thirty five on the Downs.Dead wood habitats also link with the production of fungi. Fungi are the primary cause of wood decay and play a fundamental role in the nutrient cycle for an ecosystem to function (Wesolowski, 2011). Research by Fritz and Heilmann-Clausen, (2010) concluded that knowledge of the ecological formation of microhabitats and the tree species which host them is important for the conservation of epiphytic bryophytes and lichens. Rot holes can create key microhabitats for epiphytic lichens and bryophytes on beech trees, but they can take years to develop which can have an effect on the species population that depend on them to survive (Fritz and Heilmann-Clausen, 2010). Tree cavities are an important formation for many species of mammals, insects and birds, as they provide holes suitable for nesting, breeding and resting (Remm, *et al.,* 2006). Secondary cavity nesters are dependent on the presence of existing holes rather than excavating them themselves unlike primary cavity nesters like the woodpecker (Remm, *et al.,* 2006). Existing cavities can be formed by limb breakages and decay and can encourage other species to use the cavities for breeding or nesting. Rot hole cavities were present on twenty two trees on the Low Weald and twenty one trees on the Downs and it can be concluded that from the lack of woodpecker cavities on either physiographic regions that they were most likely formed by limb breakage or removal rather than primary cavity nesters. These cavities will provide nesting sites for small birds and insects like hornets *Vespa crabro.* Woodpeckers are considered to be a keystone species in the excavation of cavities, providing resources for other species and having a direct impact on the occurrence and diversity of non- excavating species (Wesolowski, 2011). The lack of evidence to indicate that woodpeckers are producing these habitats within the farmed landscape indicates that the creations of the cavities are by limb breakage or removal. Woodpeckers are most commonly found in woodlands but their diversity has been reduced in many European forests because of management. Management processes resulted in the lack of available injured or decaying trees, reducing the diversity of tree species and tree size available (Wesolowski, 2011). This microhabitat however, can be created through natural and human induced damages.

Many of the microhabitats studied arise naturally, for example ivy, epicormic growth, fungal conks, and woodpecker cavities, although 'stress' arising from management might induce some of these. Splintered subsidiary branches, debarked areas, dead wood and broken and cut branches are features which can be caused by hedgerow management. Microhabitats like woodpecker holes which cannot be created by hedgerow management need to be deliberately added to younger trees to ensure that the microhabitats are available for species to use as a resource.

Splintered subsidiary branches, debarked areas, dead wood and broken/cut branches are just some of the microhabitats that are being inflicted on trees by humans in a project in Sweden and England. These results therefore highlight that farmland trees are producing these specialised microhabitats needed for the survival and continuation of many British species. Veteranisation projects like the Pro Natura in Sweden and the UK are being carried out to determine if human induced damage to a tree is beneficial for the conservation of microhabitats and their species which are predominantly found on ancient or veteran trees and can take hundreds of years to develop. By damaging younger trees in a specific way to mimic the trees natural response to age and heal can create precursors for microhabitats like rot hollows and debarked areas. Even though the project conducted by Pro Natura could take years for results to show, it will be able to state if human induced damages can produce microhabitats in a woodland area. It was noted that in this research there are categories of microhabitats that are being deliberately damaged on younger trees for the Pro Natura study, like debarked areas and splintered and broken branches. The results from this project therefore, highlight that farmers are unintentionally doing what these researchers have done to seek and generate microhabitats. The idea that the process of veteranisation is occurring within a farmed landscape unintentionally is something that needs to be developed and studied in more detail as it enables more trees to be available to be used in the creation of microhabitats if needed.

5.6: Implications for Farmland Management

Continuous hedgerows are crucial for the conservation of numerous species in the agricultural landscape (Dondina, *et al.,* 2016). Habitat fragmentation is one of the main threats to the populations of wildlife; therefore hedgerows are essential for maintaining connectivity between landscapes for species as without hedgerows acting as a corridor many species including bats and birds cannot travel between landscapes because of the lack of suitable habitats. However, hedgerows as an effective ecological corridor can vary because of their quality, internal structure and conditions, width and continuity (Dondina, *et al.,* 2016). There could be kilometres of hedgerows in the agricultural landscape but if they lack the quality to support the needs of the species then they cannot serve as an effective ecological habitat or corridor. This theory can be supported by the results in this project which highlight that there is a higher length of hedgerows which are lacking the structural and continuous quality needed to serve as an effective habitat and ecological corridor. There is limited information on the appropriate techniques for restoring hedgerows that are degraded so it is important that degraded and neglected hedgerows receive the correct restoration and appropriate management treatments (Croxton, *et al.,* 2004)

Changes in the way Britain's countryside is farmed can and has had a significant impact on the species richness of farmland wildlife. The shifts in Britain's farming industry caused by the increase in arable production and extensive management with the intention to boost production is the main factor contributing to the loss of Britain's hedgerows and farmland trees (Croxton, *et al.,* 2004) and consequently its wildlife, including hedgehogs, bats, turtle doves and bumblebees. Extensive evidence has highlighted that farmland birds, butterflies and small mammals have declined from the 1970s caused by the intensification of the agricultural sector with the introduction and continuous use of larger machinery and chemicals for the more specialised farming system (State of Nature, 2013).

The availability of agri-environment schemes has encouraged some British farmers to manage their farmland which still enables a sustainable efficient production of food as well as being wildlife friendly. However these schemes only work if the farmers are on board to change to wildlife friendly techniques and at the moment there are not enough farmers involved with these schemes (State of Nature, 2013).There is evidence that some agri-environment schemes have been successful at increasing species populations for example cirl bountings. If these successes are occurring in the wider landscape then practices and conservation measures can be enforced in the agricultural landscape to increase the species numbers currently in decline without causing a disadvantage to the farmers.

It is crucial for the survival of Britain's wildlife to thrive alongside the human population without the threat of decline or extinction. Increased knowledge on a wider range of species, their habitats and microhabitats needs to be undertaken because with the lack of extensive knowledge it hinders the monitoring, data recording which can be used to implement new conservation and protection measures. Biodiversity levels in Britain are indicated by the trends in farmland birds, bats and butterflies because those are the species where most research has been undertaken. Species that have received less attention for research including lichens and fungi, (State of Nature, 2013) require more extensive knowledge and research on them so that the appropriate methods for conservation and protection can be implemented. Categorising species in a particular landscape can help identify the species that need more assistance. There are specialist species that are wholly reliant on a landscape for breeding and as a food source and there are generalist species which can adapt to other habitats if their original one is disrupted or destroyed. It is the specialist species that require the most attention in making sure their habitats are always available (State of Nature, 2013). With the decline in continuous hedgerows highlighted in this research it can be concluded that the restoration, planting and sustaining of Britain's hedgerows requires more attention to ensure that species within the farmed landscape have suitable habitats always available. However, with hedgerows being neglected over the years, many have been re-categorised as lines of trees. This therefore highlights a decline in hedgerows but an increase in the potential number of trees within the agricultural landscape. It can be argued that in some cases where lines of trees have been formed in the place of a hedgerow, different habitats are being created as a result in a positive way. Farmland trees are just as important as hedgerows as functioning as a landscape and conservation resource with many species of birds, insects, bats and organisms depending on them to survive. Like hedgerows, farmland trees are an important resource in the connectivity of habitats acting as a corridor for many bird and bat species (Boughey, *et al.,* 2011). They are also an important resource for animals providing food sources, nesting and breeding places as well as protection from the weather and predators. To further understand the ecological importance that these trees bring to the agricultural landscape and the habitats they provide, this research observed the presence or absence of specialised microhabitats normally found on older woodland trees. The recommendations that emerge from this research to enhance the wildlife composition and populations in the agricultural landscape include replanting hedgerows or trees in boundary gaps in strategic locations to enhance habitat connectivity between fields and landscapes. If farmers cut branches on hedgerow trees they could use a coronet cut. A coronet cut is a technique used to simulate ragged branch ends characteristically found on broken branches caused by storm damage (Fay, 2003). A coronet cut is a facture technique which mimics that of a natural splintered subsidiary branch analysed in this project. Instead of farmers clean cutting tree branches they could practice coronet cuts to help stimulate microhabitat formation.

This research has identified that specialised microhabitats previously thought to specifically be found on older trees can be formed in younger trees on a variety of species. This highlights the positive impacts that farming management can have on the surrounding environment on being a precursor for specialised microhabitats. Farmers are already effectively veteranising young trees to a degree with debarking, splintered and broken branches on their land because of hedgerow management. If the studies conducted by Pro Natura on the veteranisation of younger trees are successful then methods could be conducted on trees in a farmland system to enhance the production of microhabitats on trees by deliberate damage. Many farmers see trees on their land as a nuisance for their machinery; therefore trees in a farmland system would benefit from this scheme and would bring them a greater ecological importance to the landscape. This would then ensure that fewer trees are removed from the farmland system enabling more trees to grow and age. This pro Natura study is evidence that long term research projects are being implemented to promote the conservation of wildlife and their habitats. There is limited research on the production of specialised microhabitats caused by management in a farmland system with many being conducted in woodland or forest areas. If a greater amount of research was undertaken to highlight how farm management is having a positive effect on the production of microhabitats then it will highlight the importance of the trees within the agricultural landscape.

6. Conclusion

This study has shown that while hedgerows and farmland trees have declined since World War Two, significant amounts still exist and provide a variety of environmental goods.

Hedgerows add visual value to the landscape, act as a habitat, food source and shelter for plants and animals and they provide habitat corridors and stepping stones in the landscape (Oreszczyn, 2000). This study has also shown that many hedgerows have become 'gappy' or overgrown which indicates the need for better management practices, to reconnect hedgerows. The effectiveness of hedgerows as ecological corridors depends on the hedge structure and its continuity (Dondina, *et al*, 2016). 'Gappy' hedgerows are less effective as habitat corridors, although they may still operate as stepping stones. The connectivity of habitats is required to assist in the genetic movement between fragmented sub populations and encourage migration along ecological corridors (Cox and Moore, 2010).

Farmland trees have in some areas increased in number as a result of hedgerow loss, leaving individual trees isolated in open fields. This occurred within the Low Weald region of this study with a total of 1077 individual trees counted in 1946 to 1900 in 2015. Isolated trees become important resources in a number of ways; first as a stepping stone between landscapes, but also, as they age, as a habitat for species including saproxylic species. A lack of habitat corridors and connectivity will affect Saproxylic species which have limited dispersal abilities and depend on the decay of older trees (Bailey, 2007).

This research is a stepping stone regarding the conservation and protection of Britain's farmland wildlife. Some of the microhabitats studied, for example rot hollows can take years to form, which is why it is crucial for research in this area to be conducted before more species and habitats go into decline or extinction.

Microhabitats such as broken branches and bark removal are occurring on farmland trees. These are two of the five microhabitats being purposely mimicked in the Pro Natura project by humans on trees to speed up the aging process to lead to the formation of these microhabitats. As these specialised microhabitats are present in the farmland system it highlights the point that even though hedge trimming on farmland can cause disruptions and destruction to the wildlife it can also be a precursor for the creation of important microhabitat features. However, while there is a good case for the veteranisation of trees to increase the number of tree microhabitats, the deliberate or accidental damage (resulting from hedge management) inflicted may also create opportunities for infection to take hold by very damaging diseases, for example, ash dieback.

There is clear evidence that years of neglect combined with the lack of extensive knowledge and awareness has caused Britain's countryside features to go into a significant decline over the decades. However, if environmental organisations, farmers and the government work together to find methods to enable having an efficient sustainable food production farming system alongside the protection of Britain's wildlife and countryside features. This increase knowledge, research and awareness would then give Britain's wildlife, plants and trees a chance to return or exceed their original numbers. Further studies need to be conducted to enhance the data in this research to highlight the importance that every hedgerow and tree brings to Britain's landscape as an ecological resource and precursor to many specialised species. Although this research was conducted on two physiographic regions, generalisations can be made that these effects and impacts have and are occurring throughout the country. The findings from this research have value for the wider lowland English countryside; especially areas described by Rackham as ancient and provide a stepping stone for the conservation and management of landscape features within the agricultural system.

This study informs the wider debate on land use, landscape change and habitat issues and fits in with previous studies and the wider literature on agricultural landscape change. This study has highlighted how numerous boundaries have been re- categorised from 1946 to 2015, supporting Bannister and Watt, (1995) who observed that boundaries classified as hedgerows in 1984 were classified as something else in 1990. This highlights how hedgerows as a resource are not being valued as an important habitat within the landscape, with numerous hedgerows being replaced with boundaries which require less maintenance, for example, wired fencing.

This study supports the work conducted by Staley *et al.,* (2012), Croxton *et al.,(* 2004), MacDonald and Jonson, (1995) Sparks and Martin, (1999) Boughey, *et al.,* (2011), Downs and Racey, (2006) Verboom and Spoelstra, (1999), Jonsell, *et al.,* (1998) Oreszcyn, (2000) and Dondina, *et al.,* (2016) concerning the important role that hedgerows provide within the environment and the crucial role they play as a habitat to many species. This study also elaborates on Vuidot, *et al.,* (2011), Winter and Moller (2008), Regnery, *et al.,* (2013), Ranius, *et al.,* (2009) and Wormington, *et al.,* (2003) who all studied the importance that hedgerows, hedgerow trees, isolated trees and mature trees are for species populations and the providence of unique specialised microhabitats. This research supports the idea that mature trees within the sites studied are producing these specialised microhabitats. It also supports, to an extent, the research by Bengtsson, *et al*. (2012) that younger trees can produce these specialised microhabitats either because of naturally induced damage or human induced. This however, needs more research to be conducted, to ensure that certain microhabitats present, for example, crown dieback and bark lesions associated with literature suggesting these are potential precursors for microhabitats to form are not signs of potentially deadly diseases.

The decline of hedgerows over the years has and continues to be a cause for concern for many of Britain's species. This study has highlighted how hedgerow length and quality between 1946 and 2015 has dramatically declined and shows that there is a long way to go too gain back the hedgerows lost over the years.

In summary the answers for the research aims stated at the beginning of this study are:

- This research has identified that the length of hedgerows studied in both the Low Weald and Downs area has declined by around half the original length between 1946 and 2015.

- This research has identified that the number of hedgerow and farmland trees increased slightly on the Low Weald between 1946 and 1960 but from 1960 to 2015 the number has declined. But there were still more in 2015 then 1946. The Downs region overall had less trees present then the Low Weald but has seen a slight increase in isolated trees between 1946 and 2015. Hedgerow trees saw an increase between 1946 and 1960 and then a decline from 1960 to 2015.

- Hedgerow loss and continuity between 1946 and 2015 has seen a decline in around half its length for both the Low Weald and the Downs. This decline on the Low Weald is explained by the increase in' gappy' hedgerows, hedgerows that have grown into a line of trees and boundaries not represented by hedgerows, for example, wired. For the Downs this can also be explained by the increased length of 'gappy' hedgerows and alternate field boundaries. Unlike the Low Weald which sees a continuous increase in these categories between 1946 and 2015, the Downs sees a continuous increase in the length of 50-90% hedged boundary from 1946 to 2015, but with the 1-50%, other boundary and boundary of trees these all increased between 1946 and 1960 but have declined slightly from 1960 to 2015. This could be an indication on changes being made towards the conservation and management of hedgerows as a field boundary.

- The Low Weald had the highest length of hedgerows measured and the most number of trees compared to the Downs. This may suggest that the Low Weald is better suited and has more land dedicated to farming.. The better fertility of the soil in the Low Weald could also explain why there is more growth then the Downs.

- It can be argued that management practices are creating some specialised microhabitats within the farmland system with all trees studied producing at least one microhabitat regardless of size and species.

This research therefore presents a detailed picture of the landscape changes that have occurred within two key physiographic regions of Kent between 1946 and 2015 and the impact it has had on its surrounding habitat and its dependent species. Studies indicating how landscape types and agricultural practices can differentially have an impact on habitat change provide an important supplement to larger scale studies.

7. References

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8. Appendix 1: Fieldwork Data

8.1: Fieldwork data for the Low Weald

Low Weald Clay	1	2	3	4	5	6
Species	Oak	Oak	Beech	Oak	Maple	Oak
DBH	N/A	N/A	N/A	N/A	N/A	N/A
Estimated Height (m)	9.14	9.11	30ft	40ft	20ft	50ft
Estimated Height of Clearance (m)	4.57	2.13	15ft	10ft	10ft	10ft
Less than 50% Crown Broken	Y	N	Y	Y	N	Y
More than 50% Crown Broken	N	Y	N	N	Y	N
Breakout/ Tearout Wound	Y	Y	Y	Y	N	N
Splintered Subsidiary Branch	Y	Y	Y	Y	Y	Y
Compression Fork Split	N	N	Y	N	N	N
Conk of Fungi	Y	N	N	N	N	N
Rot Hole Cavity	N	Y	Y	Y	N	Y
Occluding Wound	Y	Y	N	Y	N	N
Woodpecker Cavity	N	N	N	N	N	N
Cavity String	N	N	N	N	N	N
Deep Stem Cavity	N	N	N	N	N	N
Crack	N	Y	Y	Y	Y	Y
Mould/ Water/ Bark Pocket	Y	Y	Y	Y	Y	Y
Debarked Area	Y	Y	Y	Y	Y	Y
Canker	N	N	N	N	N	N
Witch Broom	N	Y	N	N	N	N
Epicormic Growth	Y	Y	N	N	Y	N
Sap Flow	N	N	N	N	N	N
Ivy (%)	60%	10%	5%	15%	80%	60%
Broken/ Cut Branches	Y	Y	Y	Y	Y	Y
Dead Wood	Y	Y	Y	Y	Y	Y
Lichens, Moss, Fungi	Y	Y	Y	Y	Y	Y
Invertebrates	Y	Y	N	Y	Y	Y
Bird Nests/ Holes	N	N	N	N	N	N
Description of Boundary	In hedgerow with nettles next to a ditch	In hedgerow with nettles next to a ditch	In hedgerow with nettles next to a ditch	In hedgerow	In hedgerow	In hedgerow
Land Use	Edge of Orchard and Rough Grassland	Edge of Orchard and Rough Grassland	Edge of Orchard and Rough Grassland	Edge of Harvested Corn Field	Edge of harvested corn field	Edge of harvested corn field
Microhabitats	13	15	12	13	11	11

7	8	9	10	11	12	13
OAK	Oak	Oak	Oak	Oak	Oak	Maple
N/A	N/A	2.032m	N/A	N/A	N/A	N/A
45FT	45ft	50ft	70ft	15ft	35ft	20ft
15FT	10ft	15ft	15ft	10ft	20ft	15ft
N	N	Y	N	Y	Y	Y
Y	Y	N	Y	N	N	N
Y	Y	Y	Y	N	Y	N
Y	Y	Y	Y	Y	Y	N
N	N	N	N	Y	N	N
N	N	N	N	N	N	N
Y	Y	Y	Y	N	Y	N
Y	Y	N	Y	N	N	N
N	N	N	N	N	N	N
N	N	N	N	N	N	N
N	N	N	N	N	N	N
Y	Y	Y	Y	N	Y	Y
Y	Y	Y	Y	Y	N	Y
Y	Y	Y	Y	Y	Y	Y
N	N	N	N	Y	N	N
N	Y	N	N	N	N	N
Y	Y	N	N	N	N	N
N	N	N	N	N	N	N
70%	70%	5%	80%	2%	5%	60%
Y	Y	Y	Y	Y	Y	Y
Y	Y	Y	Y	Y	Y	Y
Y	Y	Y	Y	Y	Y	Y
Y	N	Y	Y	N	Y	N
N	N	N	N	N	N	N
In Hedgerow	In hedgerow	In hedgerow	In hedgerow next to ditch	In hedgerow next to ditch	In hedgerow next to ditch	In hedgerow next to ditch
Edge of Harvested Corn Field	Edge of harvested corn field	Edge of harvested corn field	Edge of harvested corn field	Edge of harvested corn field	Edge of harvested corn field	Edge of harvested corn field
14	14	12	13	10	11	8

14	15	16	17	18	19	20	21	22
Oak	Oak	Oak	Oak	Oak	Ash	Oak	Oak	Oak
1.524m	1.270m	2.540m	0.914	1.397(m)	0.406	N/A	1.651	1.905
30ft	30ft	60ft	25ft	25ft	25ft	30ft	30ft	40ft
15ft	20ft	15ft	8ft	2.5ft	12ft	10ft	12ft	10ft
Y	Y	N	Y	Y	Y	Y	N	Y
N	N	Y	N	N	N	N	Y	N
Y	Y	Y	N	N	N	N	Y	N
Y	Y	Y	Y	Y	Y	Y	Y	Y
Y	N	N	N	N	N	N	N	N
N	N	Y	N	N	N	N	N	N
Y	N	Y	N	Y	N	Y	Y	N
Y	N	Y	N	N	N	N	N	N
N	N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N	N
N	N	N	N	Y	N	N	N	N
Y	Y	Y	Y	Y	Y	Y	Y	Y
Y	Y	Y	Y	Y	Y	Y	Y	Y
Y	Y	Y	Y	Y	Y	Y	Y	Y
N	N	Y	N	N	N	N	N	N
Y	N	N	Y	N	Y	Y	N	N
Y	Y	Y	N	N	Y	N	N	N
N	N	N	N	N	N	N	N	N
0%	0%	0%	10%	5%	0%	10%	5%	40%
Y	Y	Y	Y	Y	Y	Y	Y	Y
Y	Y	Y	Y	Y	Y	Y	Y	Y
Y	Y	Y	Y	Y	Y	Y	Y	Y
N	N	N	N	N	N	Y	Y	N
N	N	N	N	N	N	N	N	N
In hedgerow	In hedgerow	In hedgerow	In hedgerow	In hedgerow	In hedgerow	In hedgerow	In hedgerow	In hedgerow
Edge of harvested corn field	Edge of harvested corn field	Edge of harvested corn field	Edge of harvested corn field	Edge of harvested corn field	Edge of harvested corn field	Edge of harvested corn field	Edge of harvested corn field	Edge of harvested corn field
14	10	14	10	11	9	12	12	9

23	24	25	26	27	28	29	30	31
Oak	Oak	Oak	Oak	Oak	Oak	Oak	Oak	Oak
N/A	2.032	0.508	1.016	N/A	2.286	2.413	0.508	N/A
40ft	60ft	25ft	35ft	25ft	60ft	55ft	20ft	20ft
20ft	20ft	10ft	20ft	15ft	20ft	7ft	15ft	15ft
Y	Y	Y	Y	Y	N	N	Y	Y
N	N	N	N	N	Y	Y	N	N
Y	Y	N	N	N	Y	N	Y	N
Y	Y	Y	Y	Y	Y	Y	Y	Y
N	N	N	N	N	N	N	N	Y
N	N	N	N	N	N	N	N	N
Y	Y	N	N	N	Y	N	Y	N
Y	Y	N	N	N	Y	Y	Y	N
N	N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N	N
N	Y	N	N	N	N	N	N	N
Y	Y	N	N	N	Y	Y	Y	N
Y	Y	N	Y	Y	Y	Y	Y	Y
Y	Y	Y	Y	Y	Y	Y	Y	N
N	N	N	N	N	N	N	N	N
N	N	N	N	N	Y	Y	N	Y
N	N	N	N	N	Y	N	N	N
N	N	N	N	N	N	N	N	N
0%	0%	0%	0%	0%	0%	2%	0%	1%
Y	Y	Y	Y	Y	Y	Y	Y	Y
Y	Y	Y	Y	Y	Y	Y	Y	Y
Y	Y	Y	Y	Y	Y	Y	Y	Y
N	N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N	N
In hedgerow	In hedgerow	In hedgerow	In hedgerow	In hedgerow	In hedgerow	In hedgerow	In hedgerow	In hedgerow
Edge of harvested corn field	Edge of harvested corn field	Edge of harvested corn field	Edge of harvested corn field	Edge of harvested corn field	Edge of harvested corn field	Edge of harvested corn field	Edge of harvested corn field	Edge of harvested corn field
11	11	6	7	7	13	11	11	9

32	**33**	**34**	**35**	**36**
Oak	Oak	Oak	Oak	Oak
N/A	N/A	N/A	1.397	2.286
50ft	30ft	30ft	40ft	60ft
10ft	10ft	6ft	12ft	10ft
Y	Y	Y	Y	Y
N	N	N	N	N
Y	Y	N	Y	Y
Y	Y	Y	Y	Y
Y	N	Y	N	Y
N	N	N	N	N
Y	Y	N	Y	Y
Y	Y	N	Y	Y
N	N	N	N	N
N	N	N	N	N
N	N	N	N	N
Y	N	N	Y	Y
Y	Y	Y	Y	Y
Y	Y	Y	Y	Y
N	Y	Y	N	N
Y	Y	Y	N	Y
N	Y	Y	N	Y
N	N	N	N	N
0%	1%	2%	1%	0%
Y	Y	Y	Y	Y
Y	Y	Y	Y	Y
Y	Y	Y	Y	Y
N	N	N	N	N
N	N	N	N	N
In hedgerow	In hedgerow	In hedgerow	In hedgerow	In hedgerow
Edge of harvested corn field	Edge of harvested corn field	Edge of harvested corn field	Edge of harvested corn field	Edge of harvested corn field
13	14	12	12	14

8.2: Fieldwork Data for the Downs

Downs Chalk	1	2	3	4	5	6
Species	Ash	Elder	Oak	Sycamore	Ash	Sycamore
DBH	0.279	N/A	N/A	N/A	N/A	N/A
Estimated Height (m)	15ft	10ft	15ft	30ft	30ft	40ft
Estimated Height of Clearance (m)	4ft10	4ft	6ft	15ft	10ft	5ft
Less than 50% Crown Broken	Y	Y	Y	Y	Y	Y
More than 50% Crown Broken	N	N	N	N	N	N
Breakout/ Tearout Wound	Y	Y	Y	N	Y	Y
Splintered Subsidiary Branch	Y	Y	Y	Y	Y	Y
Compression Fork Split	N	N	Y	N	N	Y
Conk of Fungi	N	N	N	N	N	N
Rot Hole Cavity	N	Y	Y	Y	Y	Y
Occluding Wound	Y	N	N	N	Y	N
Woodpecker Cavity	N	N	N	N	N	N
Cavity String	N	N	N	N	N	N
Deep Stem Cavity	N	N	N	N	N	N
Crack	Y	Y	Y	Y	Y	Y
Mould/ Water/ Bark Pocket	Y	Y	Y	Y	Y	Y
Debarked Area	N	Y	Y	Y	Y	Y
Canker	N	N	N	N	N	N
Witch Broom	Y	Y	N	Y	N	N
Epicormic Growth	N	N	N	N	N	N
Sap Flow	N	N	N	N	N	N
Ivy (%)	0%	0%	0%	0%	70%	1%
Broken/ Cut Branches	Y	Y	Y	Y	Y	Y
Dead Wood	N	Y	Y	Y	Y	Y
Lichens, Moss, Fungi	N	N	N	N	Y	Y
Invertebrates	N	N	N	N	N	N
Bird Nests/ Holes	N	N	N	N	Y	N
Description of Boundary	Grassland	Surrounded by nettles	Surrounded by nettles	In hedgerow	In hedgerow	Standing Lone
Land Use	Wye Reserve	Edge of wheat field	Edge of wheat field	Edge of wheat field	Edge of wheat field	Edge of wheat field
Microhabitats	8	10	10	9	13	12

7	8	9	10	11	12	13	14
Sycamore	Sycamore	Ash	Ash	Douglas Fir	Douglas Fir	Douglas Fir	Douglas Fir
N/A	N/A	N/A	N/A	2.10m	N/A	1.60m	1.30m
40ft	30ft	30ft	30ft	30ft	40ft	40ft	40ft
10ft	10ft	10ft	15ft	16ft	20ft	20ft	20ft
Y	Y	Y	Y	N	N	N	N
N	N	N	N	Y	Y	Y	Y
Y	Y	N	N	Y	Y	Y	Y
Y	Y	Y	Y	N	Y	N	N
Y	Y	N	Y	N	N	N	N
N	N	N	N	N	N	N	N
N	Y	Y	N	Y	N	Y	N
N	Y	N	N	Y	N	N	N
N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N
Y	N	N	Y	N	N	N	N
Y	Y	Y	Y	N	N	N	N
N	Y	N	N	Y	N	N	N
N	N	N	N	N	N	N	N
Y	Y	Y	Y	N	N	N	N
N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N
5%	0%	0%	0%	0%	0%	0%	0%
Y	Y	Y	Y	Y	Y	Y	Y
Y	Y	Y	Y	N	N	N	Y
Y	Y	Y	Y	N	N	N	N
N	N	N	N	Y	N	N	N
N	N	N	N	N	N	N	N
Standing Lone	Standing Lone	In hedgerow	In Hedgerow	Standing Lone	Standing Lone	Standing Lone	Standing Lone
Edge of wheat field	Edge of wheat field	Between two fields of wheat	Between two fields of wheat	Field of Grassland	Field of Grassland	Field of Grassland	Field of Grassland
11	12	8	9	7	4	4	4

15	16	17	18	19	20	21	22	23
Douglas Fir	Sycamore	Oak	Oak	Oak	Oak	Sycamore	Ash	Ash
2.40m	0.80m	1.0m	2.1m	0.9m	2.5m	0.4m	N/A	N/A
25ft	10ft	20ft	30ft	10ft	50ft	10ft	15ft	20ft
6ft	5ft	3ft	4ft	7ft	2ft	2.5ft	8ft	6ft
Y	N	Y	Y	Y	Y	Y	Y	Y
N	Y	N	N	N	N	N	N	N
N	Y	Y	Y	Y	Y	N	N	N
Y	N	Y	Y	Y	Y	Y	N	N
N	N	Y	Y	N	N	N	N	Y
N	N	N	N	Y	Y	N	N	N
Y	Y	Y	Y	N	Y	Y	N	N
N	N	Y	N	N	Y	Y	N	Y
N	N	N	N	N	N	N	N	Y
N	N	N	N	N	N	N	N	N
N	N	N	N	N	Y	N	N	N
Y	N	Y	Y	Y	Y	Y	N	N
N	N	Y	Y	Y	Y	Y	N	Y
Y	N	Y	Y	Y	Y	Y	N	N
N	N	N	N	N	N	N	N	N
N	N	Y	Y	N	N	Y	N	N
N	N	Y	Y	N	Y	N	N	N
N	N	N	Y	N	N	N	N	N
0%	0%	0%	0%	0%	0%	0%	100%	100%
Y	Y	Y	Y	Y	Y	Y	Y	Y
Y	Y	Y	Y	Y	Y	Y	Y	Y
N	Y	N	Y	N	Y	N	Y	Y
N	N	Y	Y	N	N	Y	Y	Y
N	N	N	N	N	N	N	Y	Y
Standing Lone	Standing Lone	Standing Lone	Standing Lone	Standing Lone	Standing Lone	Standing Lone	Standing Lone	Standing Lone
Field of Grassland	Field of grassland and cows	Edge of field of crops	Edge of field of crops	Edge of field of crops	Edge of field of crops	Edge of field of crops	Middle of Corn field	Middle of Corn field
7	6	14	15	9	14	11	7	11

24	25	26	27	28	29	30	31	32
Ash	Ash	Ash	Ash	Ash	Ash	Ash	Sycamore	Oak
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
30ft	40ft	20ft	20ft	20ft	20ft	25ft	30ft	35ft
20ft	10ft	18ft	10ft	5ft	10ft	8ft	6ft	6ft
Y	N	N	Y	N	Y	Y	Y	Y
N	Y	Y	N	Y	N	N	N	N
Y	Y	N	N	Y	Y	N	Y	Y
N	Y	N	Y	Y	N	Y	Y	Y
Y	N	Y	N	N	Y	N	N	N
N	N	N	N	Y	Y	N	N	N
Y	Y	N	N	Y	Y	Y	Y	N
Y	Y	N	N	Y	Y	N	Y	N
N	N	N	N	Y	N	N	N	N
N	N	N	N	Y	N	N	N	N
N	N	N	N	Y	N	N	N	N
N	N	N	N	Y	N	N	N	N
Y	Y	Y	Y	Y	Y	Y	Y	Y
N	Y	N	N	Y	N	N	N	N
N	Y	N	N	N	N	N	N	N
N	N	N	N	N	N	Y	N	N
N	N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N	N
0%	0%	0%	80%	2%	0%	0%	50%	40%
Y	Y	Y	N	Y	Y	Y	Y	Y
Y	Y	Y	N	Y	N	N	Y	Y
Y	N	N	Y	Y	Y	Y	Y	Y
Y	N	N	N	N	N	N	N	N
Y	N	N	N	Y	N	N	N	N
Standing Lone	Standing Lone	Standing Lone	Standing Lone	Standing Lone	Standing Lone	In Hedgerow	In Hedgerow	In Hedgerow
Middle of Corn field	Edge of field	Edge of field	Edge of field	Edge of field	Edge of field	Edge of field with crops	Edge of Corn field on bank	Edge of Corn field on bank
11	10	5	5	17	9	7	10	8

33	34	35
Oak	Beech	Beech
N/A	N/A	N/A
35ft	25ft	30ft
10ft	10ft	8ft
Y	Y	Y
N	N	N
Y	N	N
Y	N	N
N	N	N
N	N	N
N	N	N
Y	N	N
N	N	N
N	N	N
N	N	N
Y	N	N
Y	N	N
Y	N	N
N	N	N
Y	Y	Y
N	N	N
N	N	N
80%	100%	100%
Y	N	N
Y	N	N
Y	N	N
N	N	N
N	Y	N
In Hedgerow	In Hedgerow	In Hedgerow
Edge of Corn field on bank	Edge of Corn field on bank	Edge of Corn field on bank
12	4	3

8.3: Fieldwork Data for the Ashdown Beds

Ashdown Beds	1	2	3	4	5	6	7
Species	Beech	Beech	Oak	Holly	Sycamore	Sycamore	Sycamore
DBH	N/A	N/A	N/A	N/A	1.2	1.8	1.5
Estimated Height (m)	2.947	4.319	3.116	3.598	5.168	4.031	4.587
Estimated Height of Clearance (m)	-	-	-	-	-	-	-
Less than 50% Crown Broken	Y	Y	Y	Y	Y	Y	N
More than 50% Crown Broken	N	N	N	N	N	N	Y
Breakout/ Tearout Wound	N	N	N	N	N	N	Y
Splintered Subsidiary Branch	Y	Y	Y	Y	Y	Y	Y
Compression Fork Split	Y	Y	N	N	Y	Y	Y
Conk of Fungi	N	N	N	N	N	N	N
Rot Hole Cavity	N	N	N	N	N	N	N
Occluding Wound	Y	N	Y	Y	N	N	Y
Woodpecker Cavity	N	N	N	N	N	N	N
Cavity String	N	N	N	N	N	N	N
Deep Stem Cavity	N	N	N	N	N	N	N
Crack	N	N	N	N	N	N	Y
Mould/ Water/ Bark Pocket	N	N	N	N	N	N	N
Debarked Area	N	N	Y	Y	N	N	Y
Canker	N	N	N	N	N	N	N
Witch Broom	N	N	N	N	N	N	N
Epicormic Growth	N	N	N	N	N	N	N
Sap Flow	N	N	N	N	N	N	N
Ivy (%)	10%	60%	0%	0%	80%	80%	10%
Broken/ Cut Branches	Y	Y	N	N	Y	N	Y
Dead Wood	N	N	N	N	N	N	N
Lichens, Moss, Fungi	Y	Y	N	N	Y	Y	Y
Invertebrates	N	N	N	N	N	N	N
Bird Nests/ Holes	N	N	N	N	N	N	N
Description of Boundary	Dense Hederow with brambles	Dense Hederow with brambles	Dense Hederow with brambles	Dense Hederow with brambles	Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence
Land Use	Grassland	Grassland	Grassland	Grassland/	Grassland/	Grassland/	Grassland/

	/ Pasture	/ Pasture	/ Pasture	Pasture	Pasture	Pasture	Pasture
Microhabitats	7	6	4	4	6	5	10

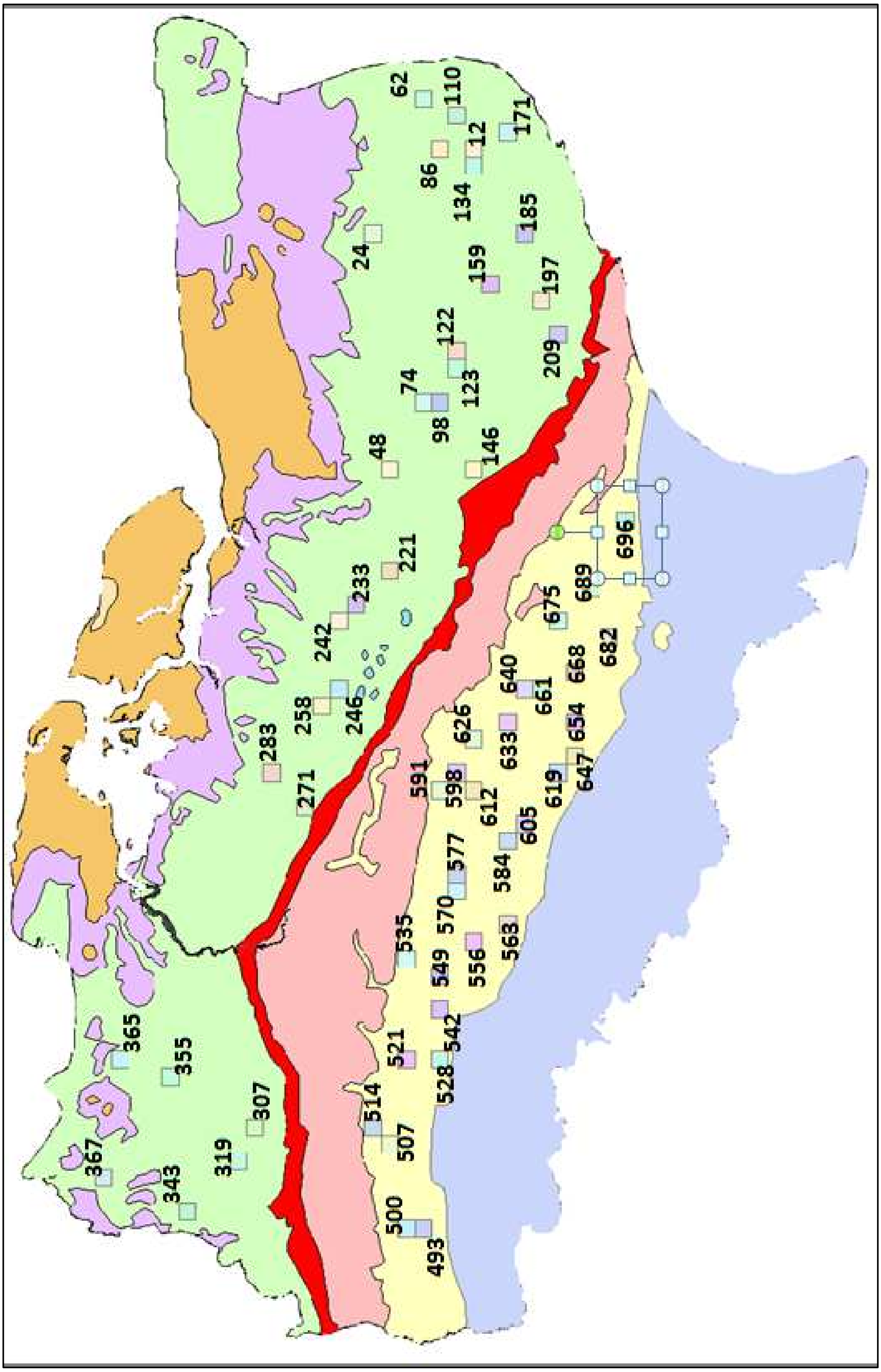
8	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Beech	Sycamore	Sycamore	Sycamore	Sycamore	Sycamore	Sycamore	Sycamore
1.05	0.45	1.5	0.9	0.65	1	0.8	1.8
3.855	4.042	6.495	4.761	5.2	3.413	7.214	5.495
-	-	-	-	-	-	-	-
N	Y	Y	Y	N	Y	N	Y
Y	N	N	N	Y	N	Y	N
N	N	Y	N	Y	Y	Y	N
Y	Y	Y	Y	Y	Y	Y	Y
Y	N	Y	Y	Y	Y	Y	Y
Y	N	N	N	N	N	N	N
N	N	Y	N	N	N	N	N
N	N	Y	N	Y	Y	Y	Y
N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N
N	N	Y	N	Y	N	Y	Y
N	N	N	N	N	N	N	N
N	N	Y	N	Y	Y	Y	N
N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N
80%	90%	10%	90%	20%	10%	10%	50%
Y	N	Y	Y	Y	Y	Y	Y
N	N	N	N	N	N	N	N
Y	Y	Y	Y	Y	Y	Y	Y
N	N	Y	N	N	N	N	N
N	N	N	N	N	N	N	N
Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence
Grassland/ Pasture	Grassland/ Pasture	Grassland/ Pasture	Grassland/ Pasture	Grassland/ Pasture	Grassland/ Pasture	Grassland/ Pasture	Grassland/ Pasture
7	4	12	6	10	9	10	8

16	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Sycamore	Sycamore	Sycamore	Sycamore	Sycamore	Ash	Oak	Sycamore
0.53	1.2	1.4	0.8	0.65	1.2	1.8	0.44
4.48	5.253	5.5	4.423	3.533	5.458	8.602	4.479
-	-	-	-	-	-	-	-
Y	Y	Y	Y	N	N	Y	Y
N	N	N	N	Y	Y	N	N
Y	Y	Y	Y	Y	Y	Y	Y
Y	Y	Y	Y	Y	Y	Y	Y
Y	Y	Y	N	Y	Y	Y	Y
Y	N	N	N	N	N	Y	N
Y	Y	Y	N	N	N	Y	Y
Y	N	Y	N	Y	Y	Y	Y
N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N
Y	N	Y	Y	Y	Y	Y	N
N	N	N	N	N	N	N	N
Y	Y	Y	Y	Y	Y	Y	Y
N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N
5%	0%	30%	40%	5%	5%	5%	0%
Y	Y	Y	N	Y	Y	Y	Y
N	N	N	N	N	Y	Y	Y
Y	N	Y	Y	Y	Y	Y	N
Y	N	N	N	Y	Y	N	N
N	N	N	N	N	N	N	N
Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence
Grassland/ Pasture	Grassland/ Pasture	Grassland/ Pasture	Grassland/ Pasture	Grassland/ Pasture	On the edge of a wheatfield	On the edge of a wheatfield	On the edge of a wheatfield
13	7	11	7	11	12	13	9

24	25	26	27	28	29	30	31
Silver Birch	Silver Birch	Silver Birch	Silver Birch	Silver Birch	Beech	Silver Birch	Silver Birch
0.8	0.8	0.7	0.96	1.05	0.53	0.51	0.57
6.606	5.841	5.072	4.242	4.859	3.599	5.71	5.231
-	-	-	-	-	-	-	-
Y	Y	N	Y	Y	Y	Y	N
N	N	Y	N	N	N	N	Y
Y	N	Y	Y	Y	Y	Y	Y
Y	Y	Y	Y	Y	Y	Y	Y
N	Y	Y	Y	Y	Y	Y	N
Y	N	Y	N	N	N	Y	N
N	N	Y	N	Y	N	N	N
Y	Y	Y	Y	Y	N	Y	Y
N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N
Y	N	Y	Y	Y	Y	Y	Y
N	N	N	N	N	N	N	N
Y	Y	Y	Y	Y	Y	Y	Y
N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N
N	N	N	N	N	N	N	N
0%	0%	0%	0%	10%	50%	5%	10%
Y	Y	Y	Y	Y	N	Y	Y
N	N	Y	Y	N	N	N	N
N	N	N	N	Y	Y	Y	Y
N	N	Y	N	N	N	N	N
N	Y	N	Y	N	N	N	N
Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence
On the edge of a wheatfield	On the edge of a wheatfield	On the edge of a wheatfield	On the edge of a wheatfield	On the edge of a wheatfield	On the edge of a wheatfield	On the edge of a wheatfield	On the edge of a wheatfield
8	7	12	10	11	8	11	9

32	33	34	35	36	37
Silver Birch	Silver Birch	Beech	Oak	Ash	Oak
0.82	0.5	1.22	0.6	0.2	0.6
6.891	5.371	5.771	4.511	4.444	6.384
-	-	-	-	-	-
Y	Y	Y	N	N	N
N	N	N	Y	Y	Y
Y	Y	Y	N	Y	Y
Y	Y	Y	Y	Y	Y
Y	N	Y	Y	Y	N
N	N	N	N	N	N
Y	N	N	N	N	N
Y	Y	Y	N	Y	Y
N	N	N	N	N	N
N	N	N	N	N	N
N	N	N	N	N	N
Y	Y	Y	N	N	Y
N	N	N	N	N	N
Y	Y	N	N	Y	Y
N	N	N	N	N	N
N	N	N	N	N	N
N	N	N	N	N	N
N	N	N	N	N	N
0%	0%	20%	60%	0%	0%
Y	N	N	Y	Y	Y
N	N	N	N	N	Y
N	N	Y	Y	N	N
Y	Y	Y	Y	N	N
N	N	N	N	N	N
Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence	Individual tree alongside fence
On the edge of a wheatfield	On the edge of a wheatfield	On the edge of a wheatfield	On the edge of a wheatfield	On the edge of a wheatfield	On the edge of a wheatfield
10	7	9	7	7	8

9. Appendix 2: Sample Square Locations



9.1: Key for Digitized Squares

Key

For each sample square the following features were digitized on top of the aerial image for the chosen years studied. Individual trees, hedgerow trees and trees forming a boundary were also individually counted

- Pink Line – 90-100% Hedged Boundary
- Yellow Line – 50-90% Hedged
- Orange Line – 1-50% Hedged
- Purple Line – Other Boundary (Wired, wooden or grass verge)
- Green Line – Tree Boundary
- Green Block – Woodland/ Shrubland
- Pink Block - Orchard